US007116191B2

(12) **United States Patent**
**Wang**

(10) **Patent No.: US 7,116,191 B2**
(45) **Date of Patent: Oct. 3, 2006**

(54) **GROUND FAULT CIRCUIT INTERRUPTER WITH REVERSE WIRING PROTECTION**

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(73) Assignee: **Wenzhou Sansheng Electrical Co., Ltd.**, (CN)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **11/072,855**

(22) Filed: **Mar. 3, 2005**

(65) **Prior Publication Data**

US 2006/0044087 A1 Mar. 2, 2006

**Related U.S. Application Data**

(63) Continuation-in-part of application No. 10/945,672, filed on Sep. 21, 2004.

(30) **Foreign Application Priority Data**

Sep. 1, 2004 (CN) ........................ 2004 2 0079238
Feb. 8, 2005 (CN) ........................ 2005 1 0007673

(51) **Int. Cl.**
***H01H 73/00*** (2006.01)

(52) **U.S. Cl.** ........................................... **335/18**; 361/42

(58) **Field of Classification Search** .................. 335/18; 361/42
See application file for complete search history.

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(57) **ABSTRACT**

A circuit interrupter comprises a pair of fixed contact strips, a pair of load contact strips, a pair of movable contact strips, a reset component, a movable component, and a tripping component that contains a reset contact. Each of the fixed contact strips has a fixed contact. Each of the load contact strips has a load contact. Each of the movable contact strips has a fixed end and a movable end. Each movable end has a first movable contact arranged for contacting one of the corresponding load contacts and a second movable contact arranged for contacting one of the corresponding fixed contacts. The movable component disposed to sustain the movable ends of the movable contact strips, the movable component capable of either being latched with or released from the reset component to move between a first position where the first movable contacts are separated from the load contacts, and the second movable contacts are separated from the fixed contacts, and the movable contact strips are not electrically coupled to the reset contact, a second position where the first movable contacts are separated from the load contacts, and the second movable contacts are separated from the fixed contacts, and at least one of the movable contact strips is electrically coupled to the reset contact, and a third position where the first movable contacts make contact with the corresponding load contacts, and the second movable contacts make contact with the corresponding fixed contacts, and the movable contact strips are not electrically coupled to the reset contact. The tripping component is capable of latching the reset component with the movable component for the movable component to move to the third position upon detection of a reset request and releasing the reset component from the movable component for movable component to move to the first position upon detection of a fault condition.

**32 Claims, 18 Drawing Sheets**

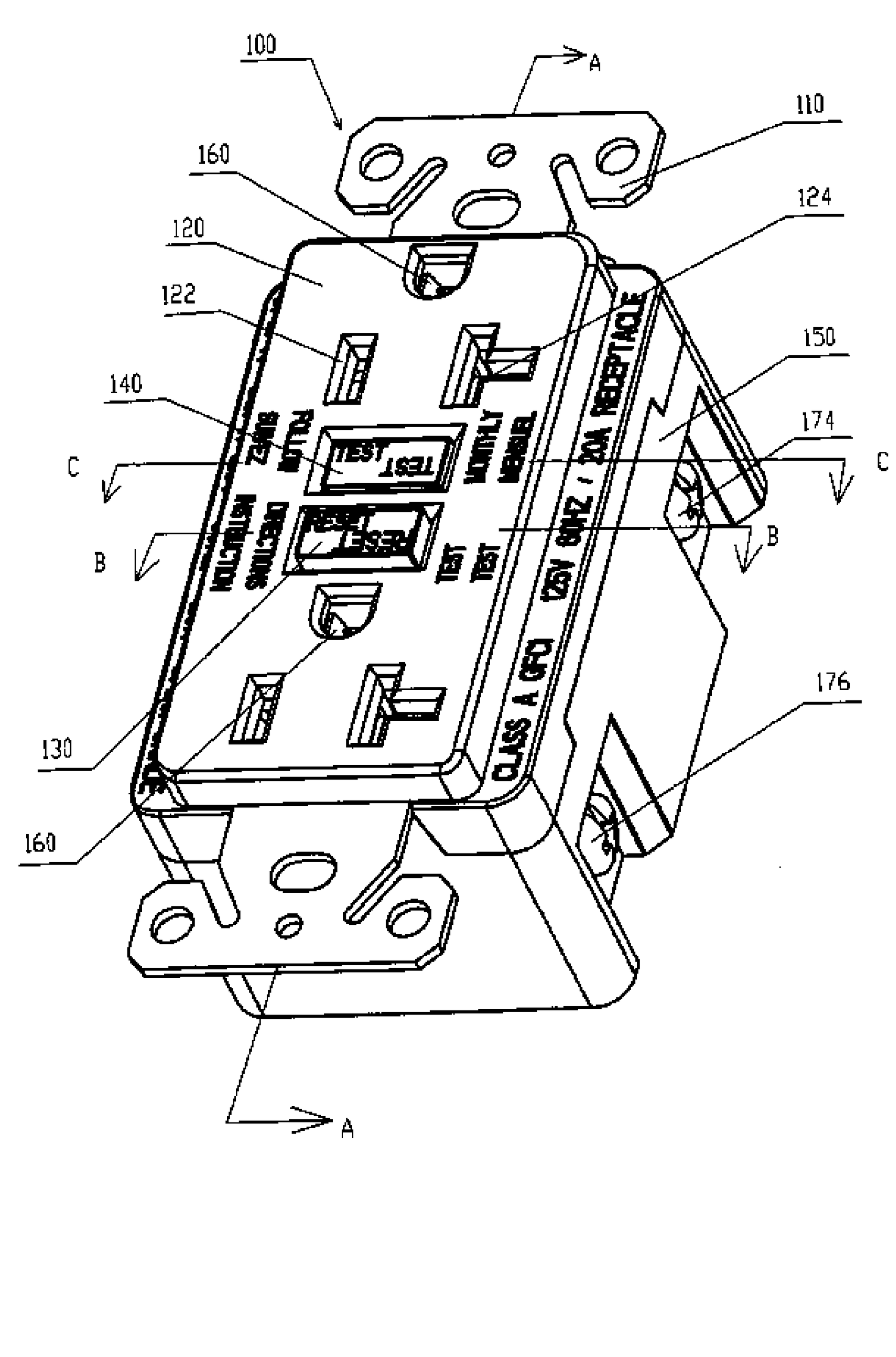
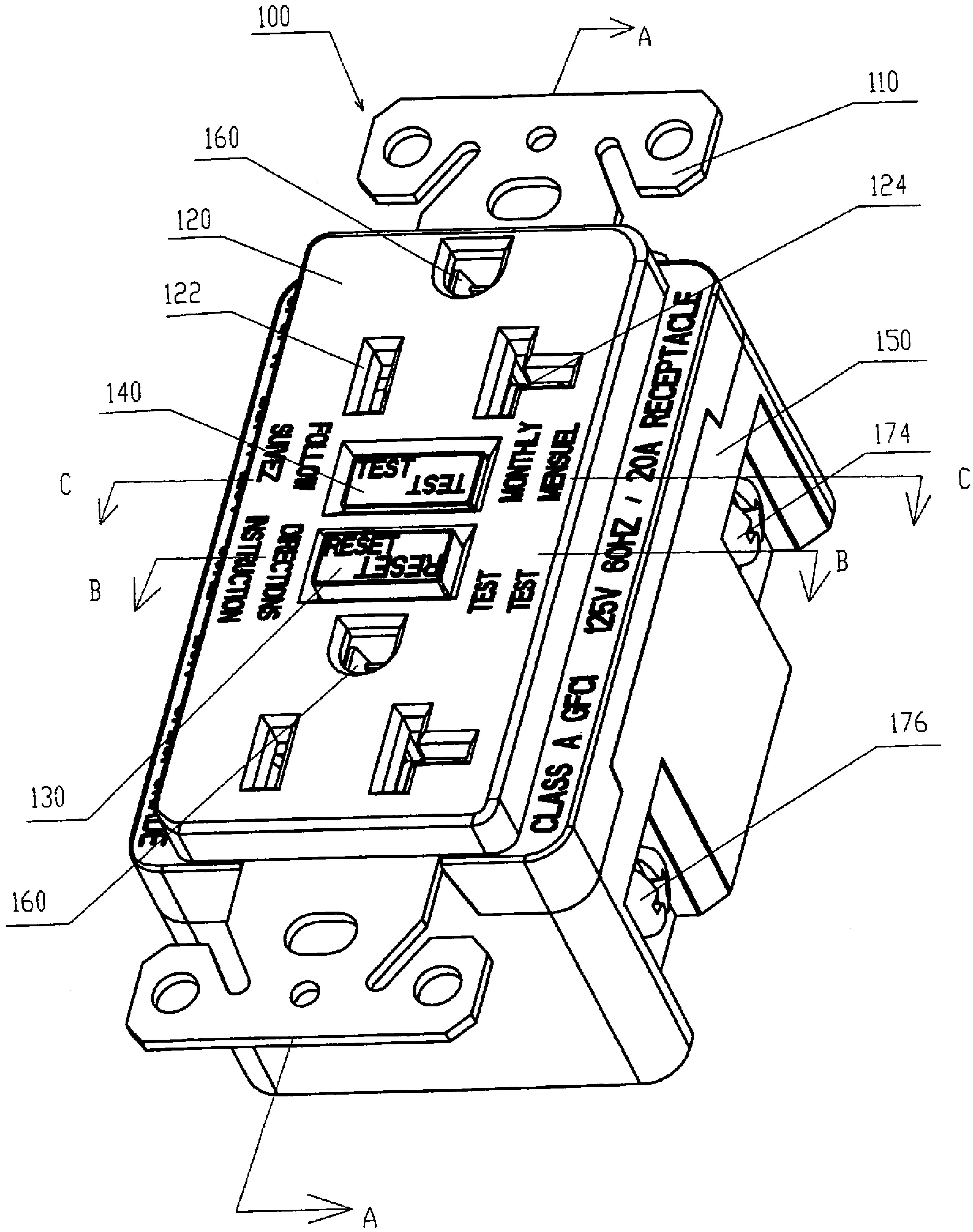


FIG.1



100
110
160
124
120
122
150
140
174
C
C
B
B
FOLLOW
SUIVEZ
TEST
TEST
RESET
RESET
DIRECTIONS
INSTRUCTION
MONTHLY
MENSUEL
TEST
TEST
125V 60HZ / 20A RECEPTACLE
CLASS A GFCI
176
130
160
A
A

FIG.2

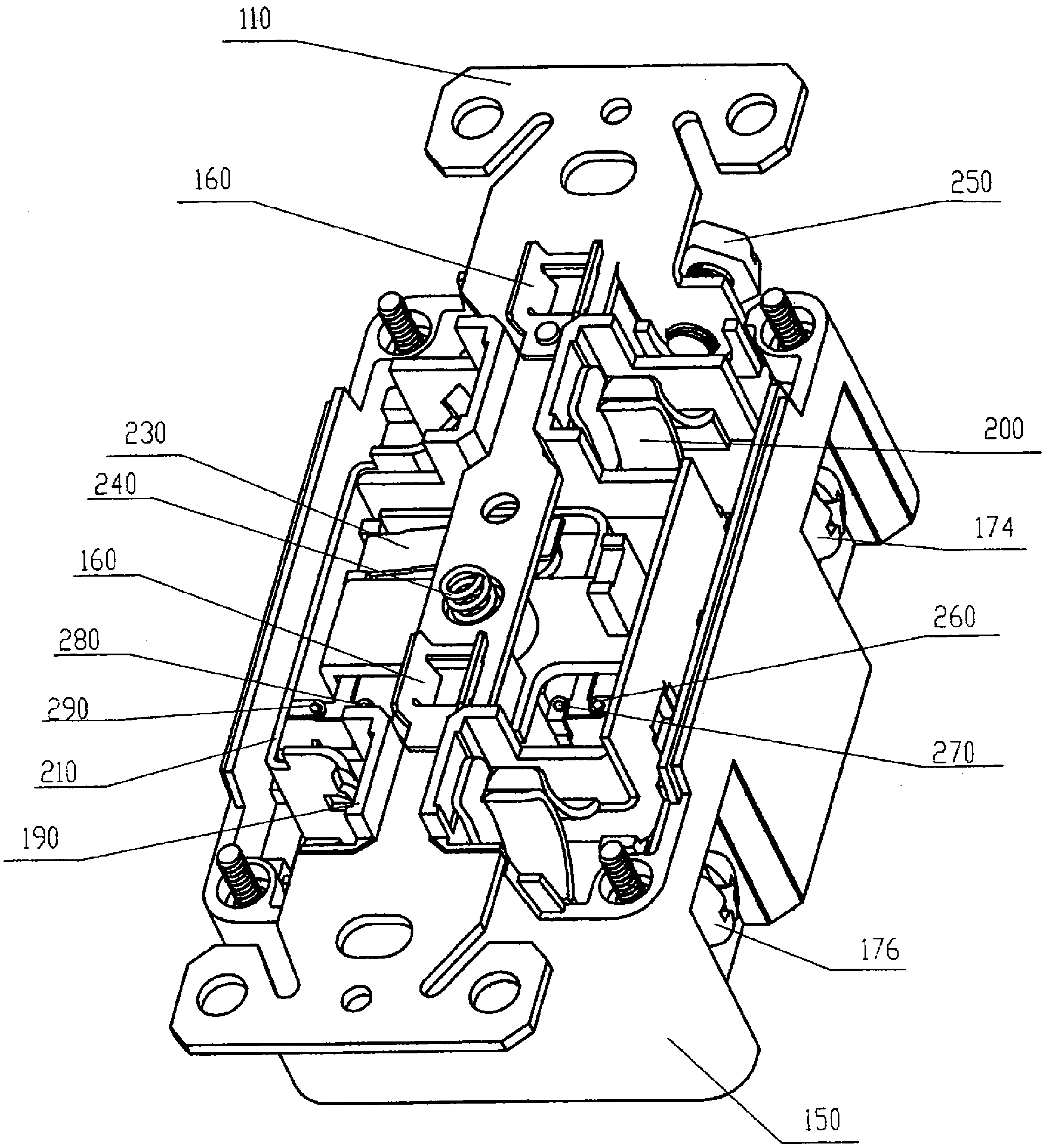
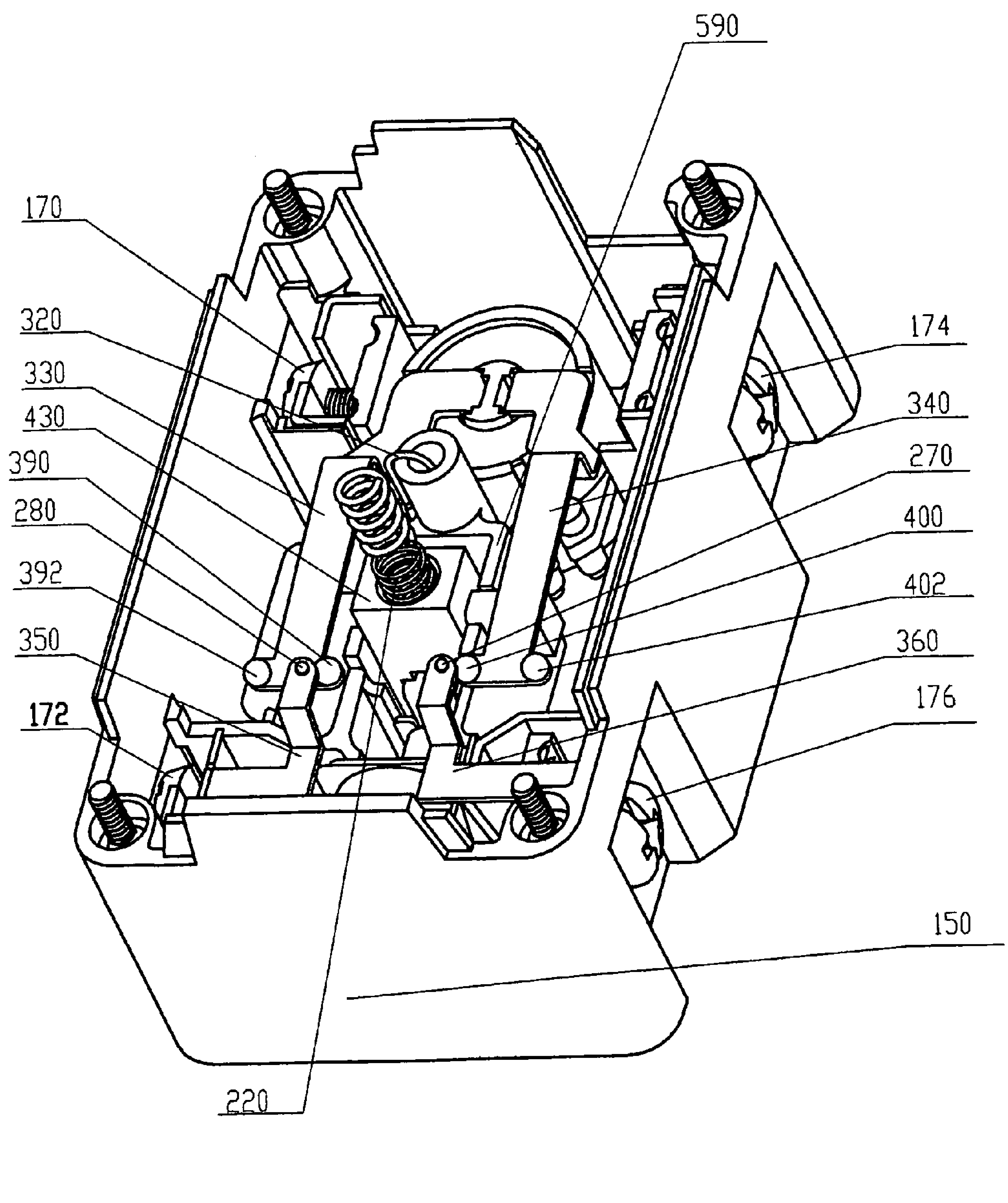


FIG.3A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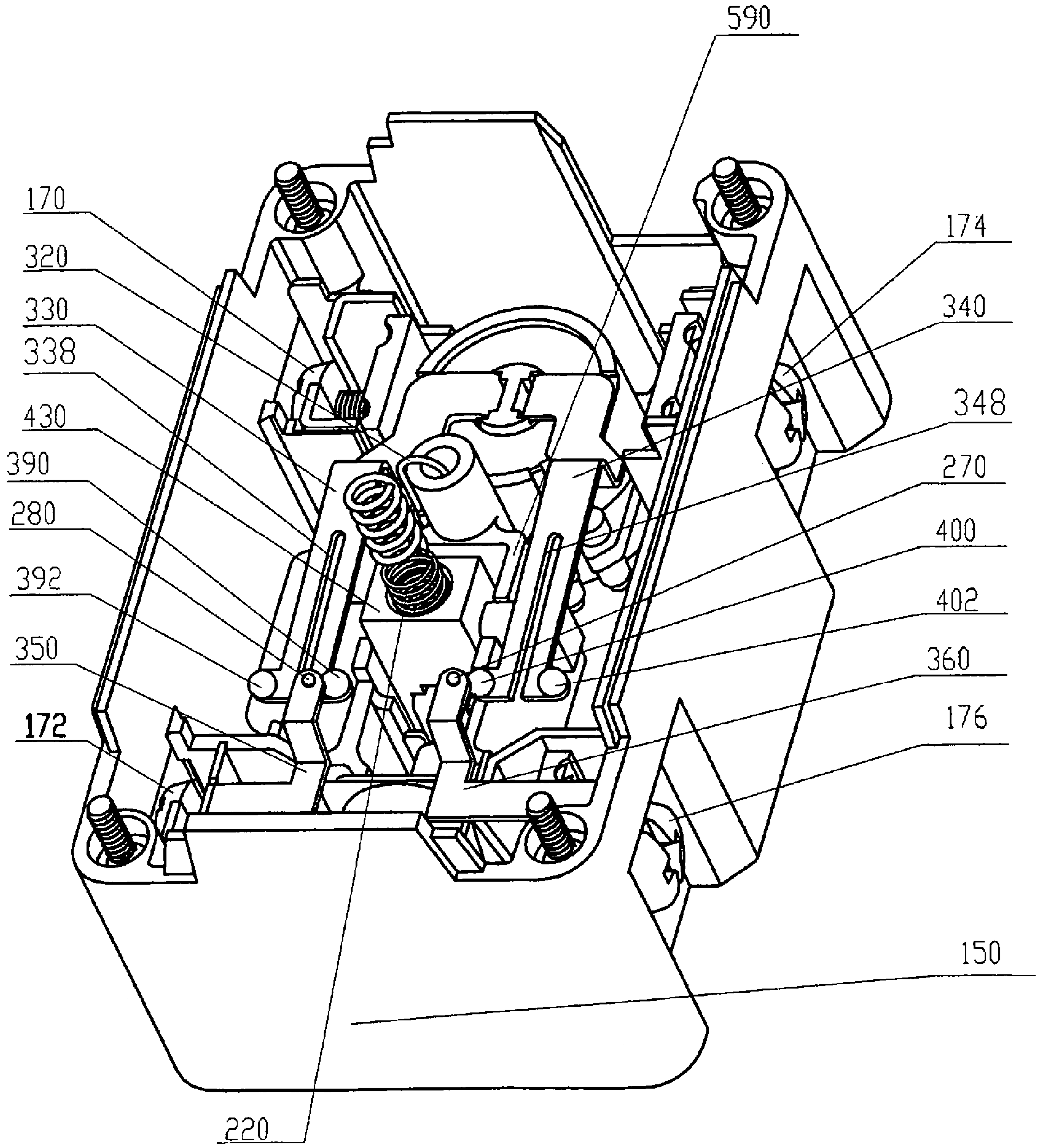
170
320
330
430
390
280
392
350
172
174
340
270
400
402
360
176
150
220

FIG.3B


590
170
320
330
338
430
390
280
392
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172
174
340
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270
400
402
360
176
150
220

FIG.4

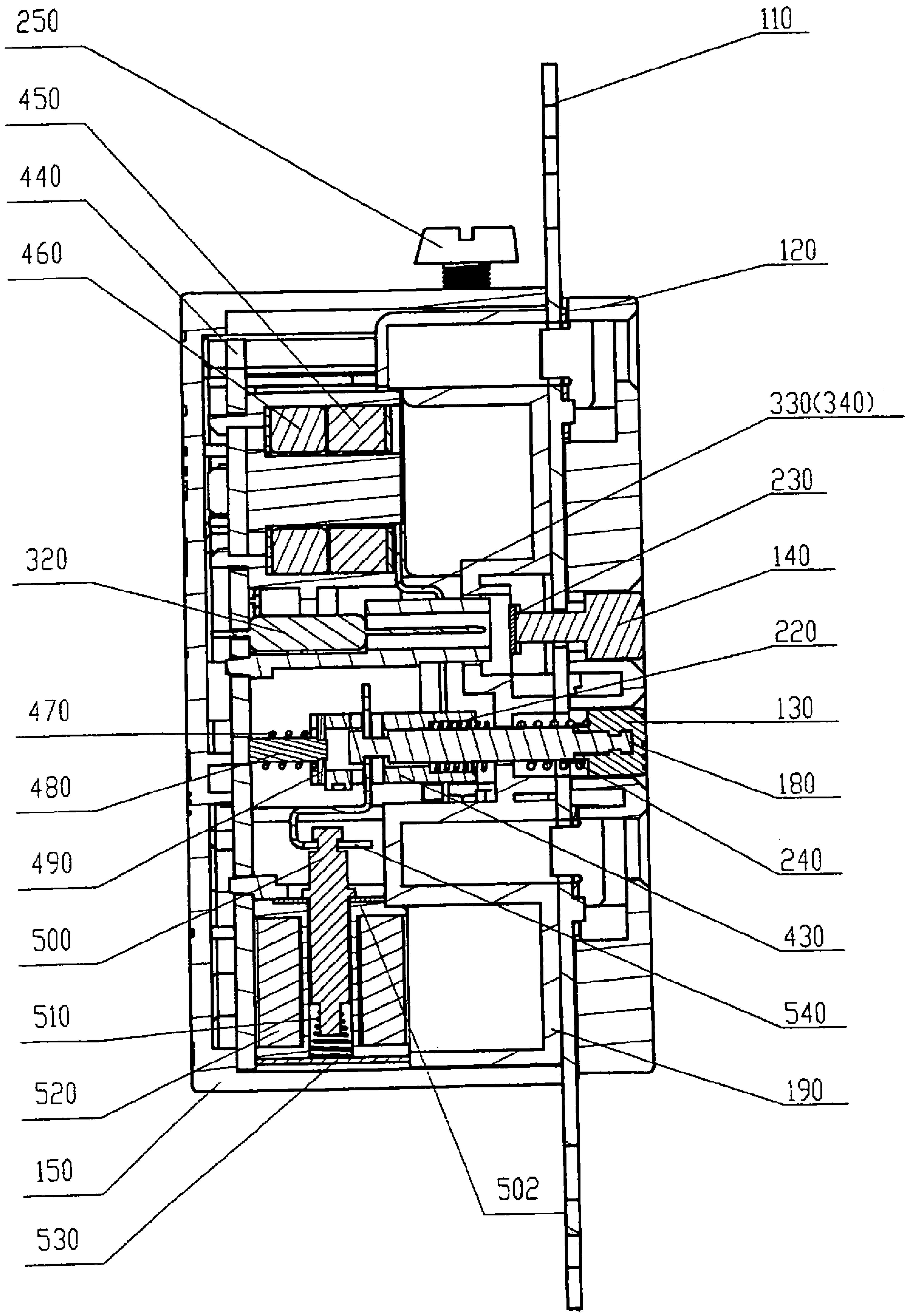
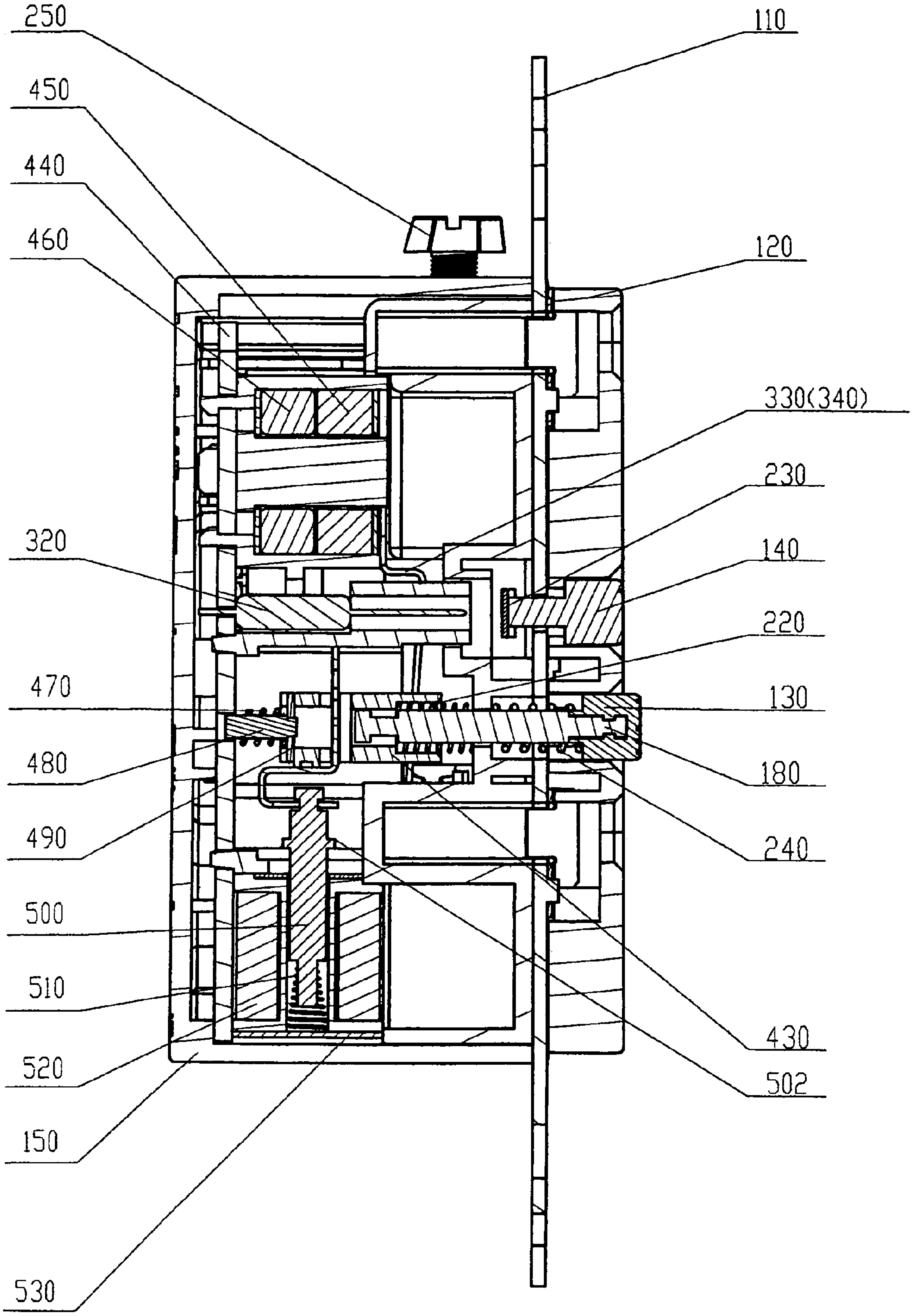

250
450
440
460
320
470
480
490
500
510
520
150
530
110
120
330(340)
230
140
220
130
180
240
430
540
190
502

FIG.5


250
450
440
460
320
470
480
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530
110
120
330(340)
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140
220
130
180
240
430
502

FIG.6

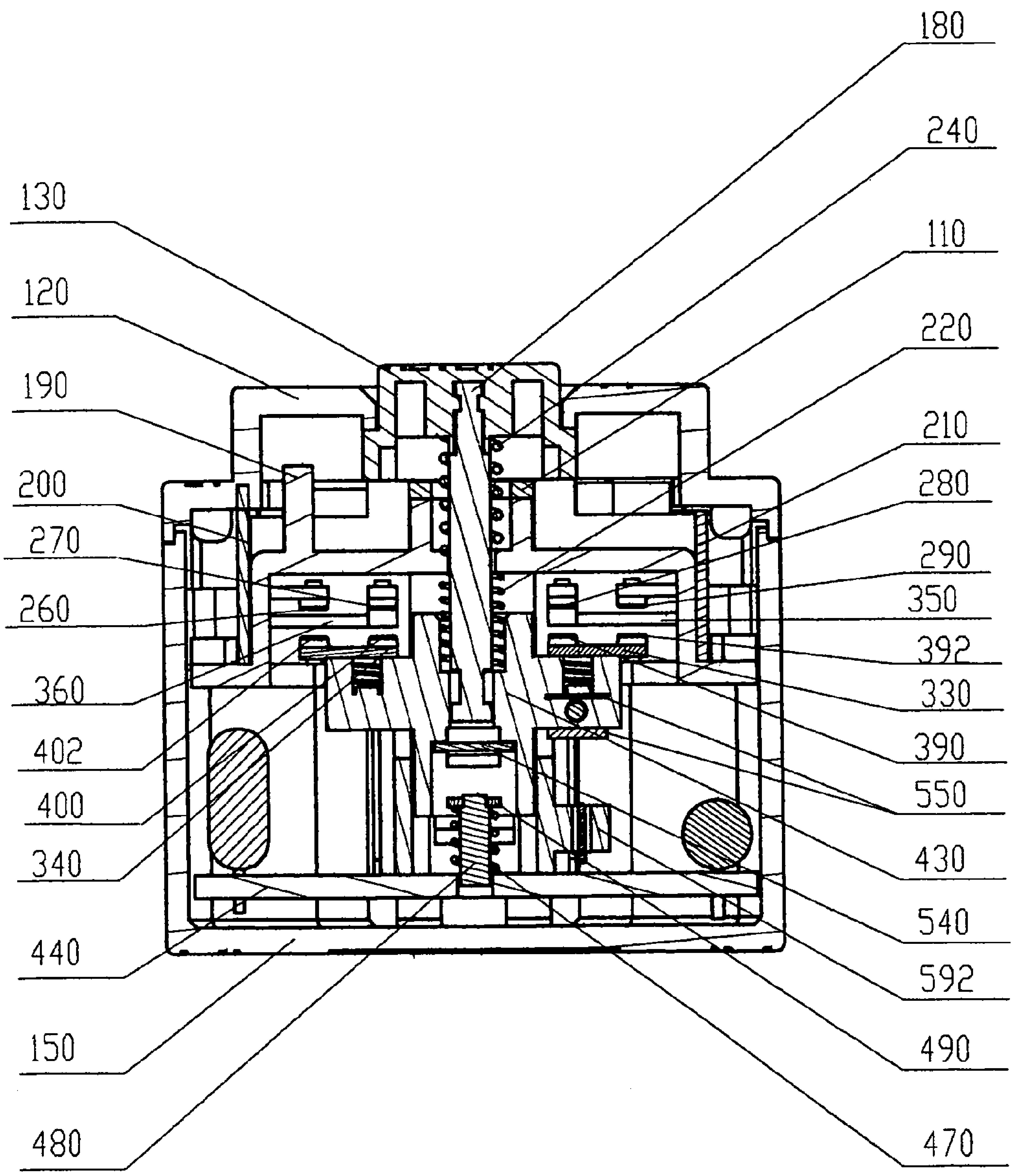

180
240
110
220
210
280
290
350
392
330
390
550
430
540
592
490
470
130
120
190
200
270
260
360
402
400
340
440
150
480

FIG.7

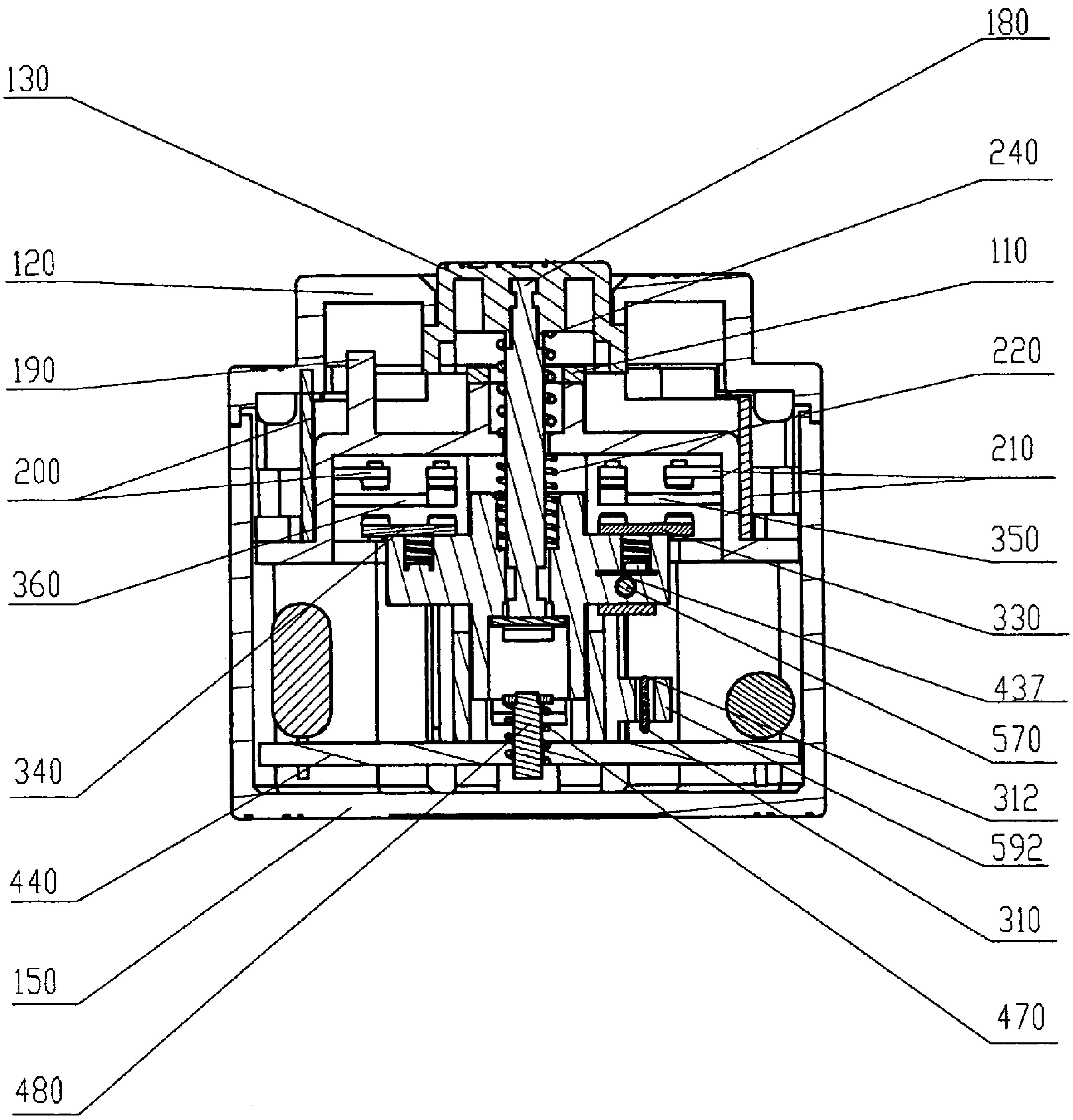

180
130
240
120
110
190
220
200
210
350
360
330
437
570
340
312
592
440
310
150
470
480

FIG.8

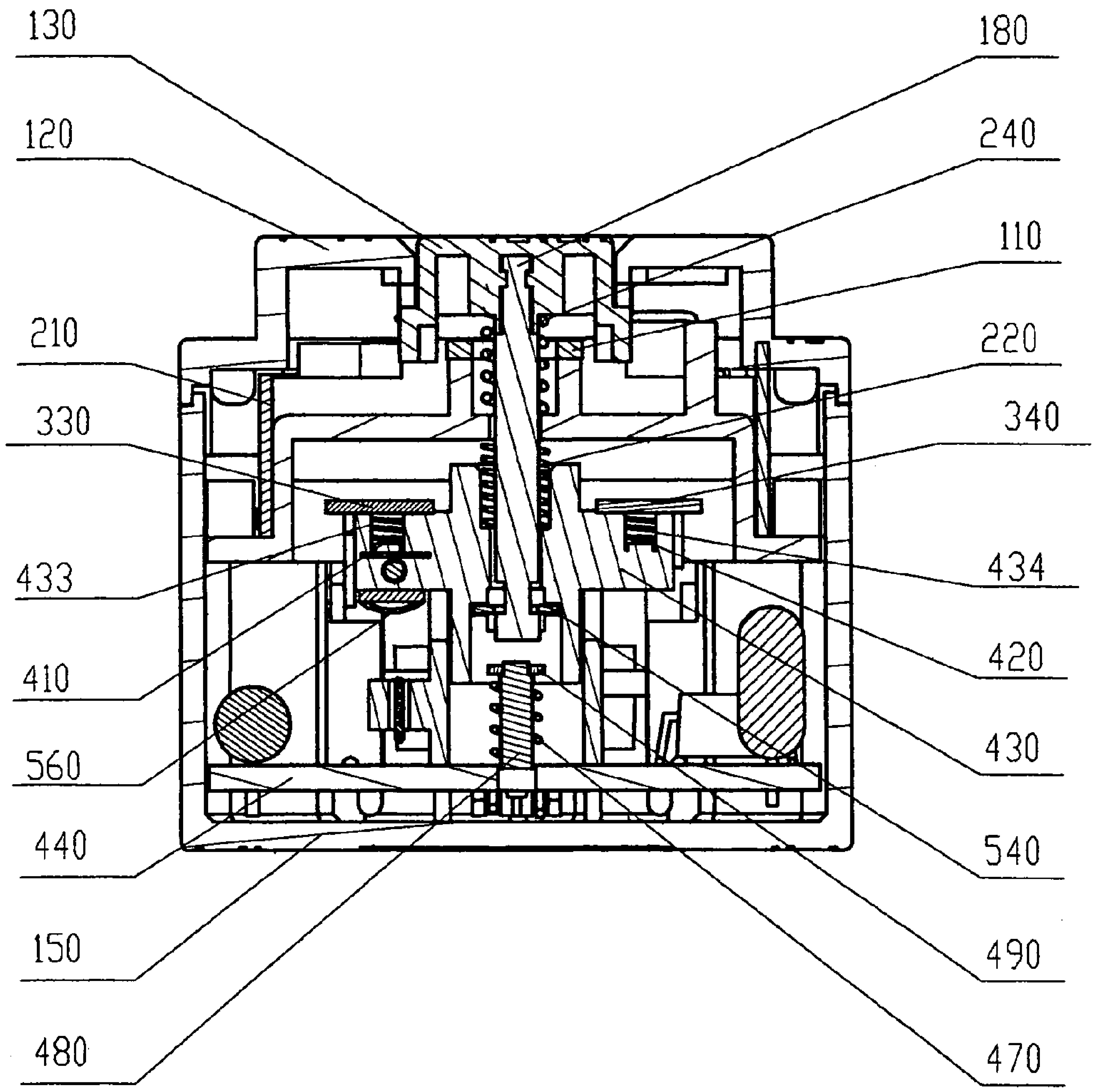
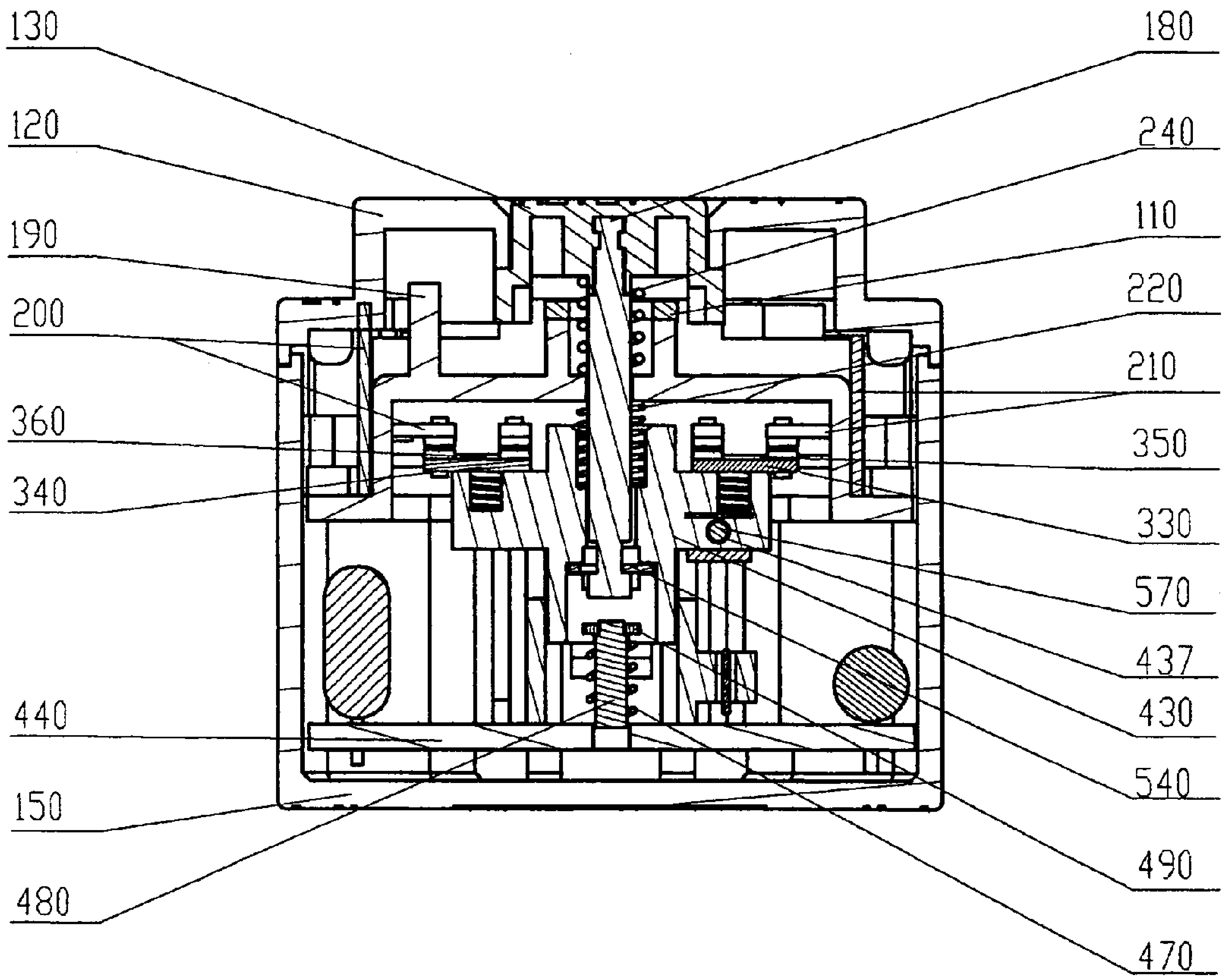

130
180
120
240
110
210
220
330
340
433
434
410
420
560
430
440
540
150
490
480
470

FIG.9


130
120
190
200
360
340
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150
480
180
240
110
220
210
350
330
570
437
430
540
490
470

FIG.10

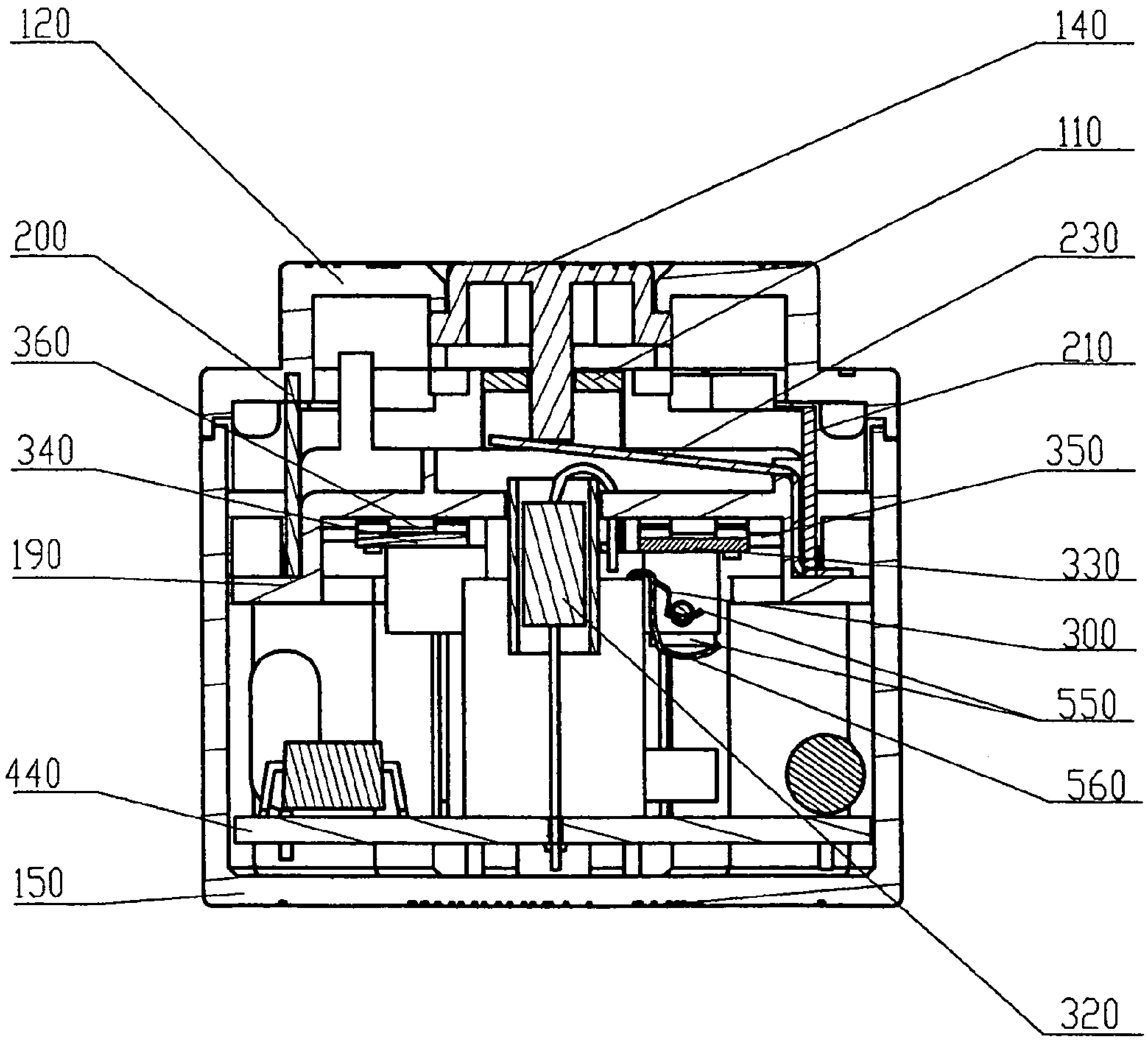
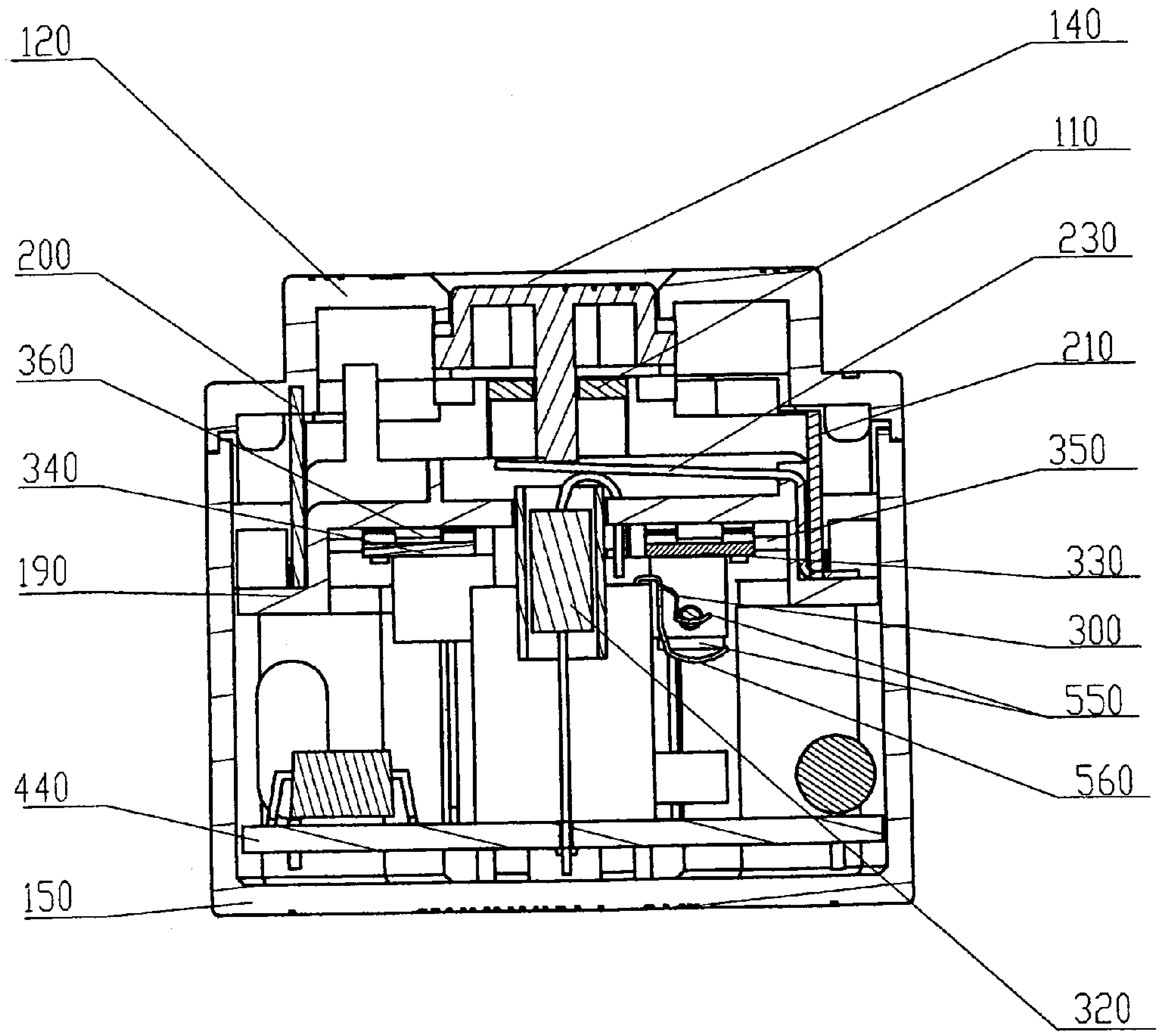

120
140
110
200
230
360
210
340
350
190
330
300
550
440
560
150
320

FIG.11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230
210
200
360
340
190
350
330
300
550
560
440
150
320

FIG.12

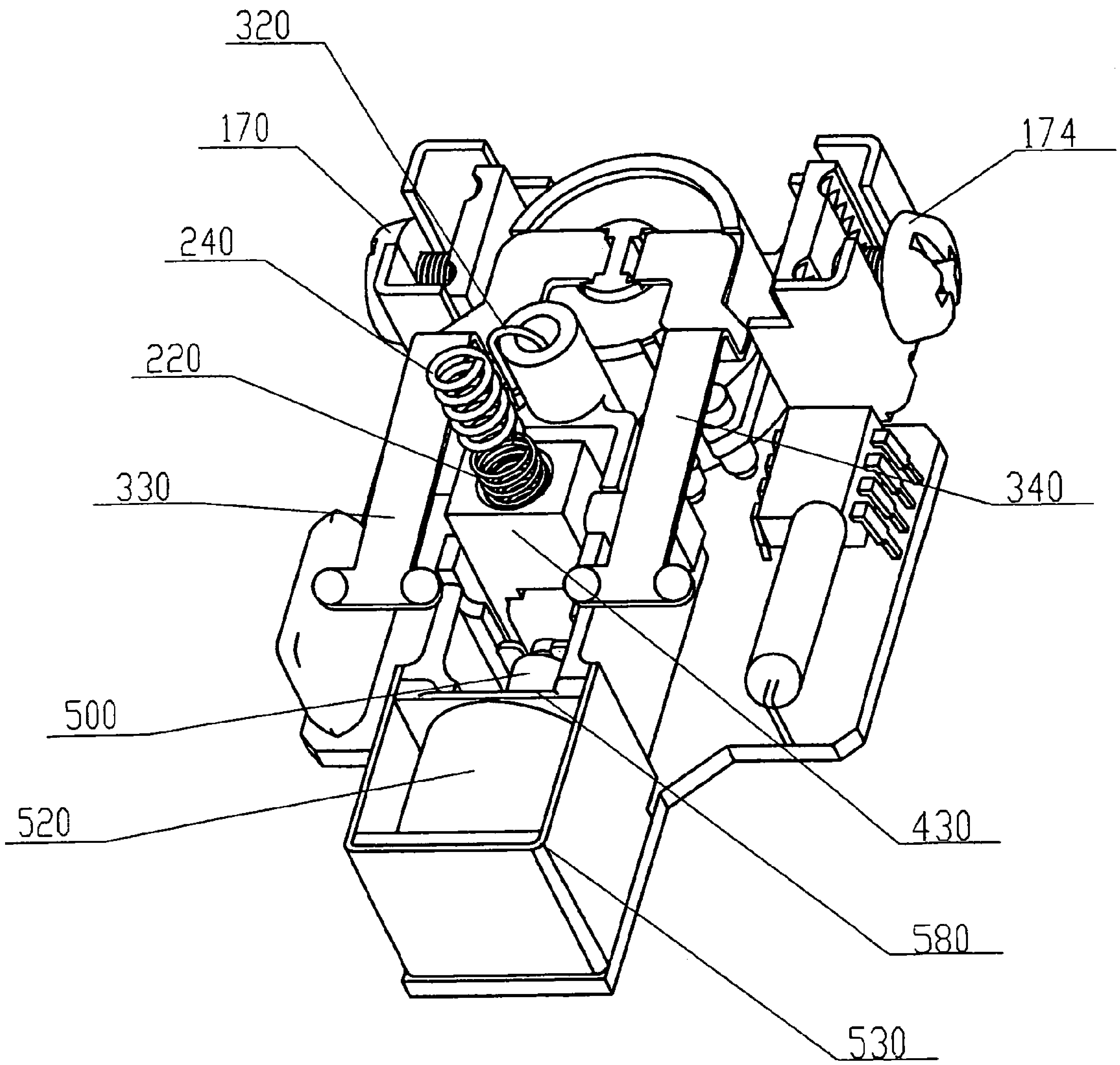


FIG.13

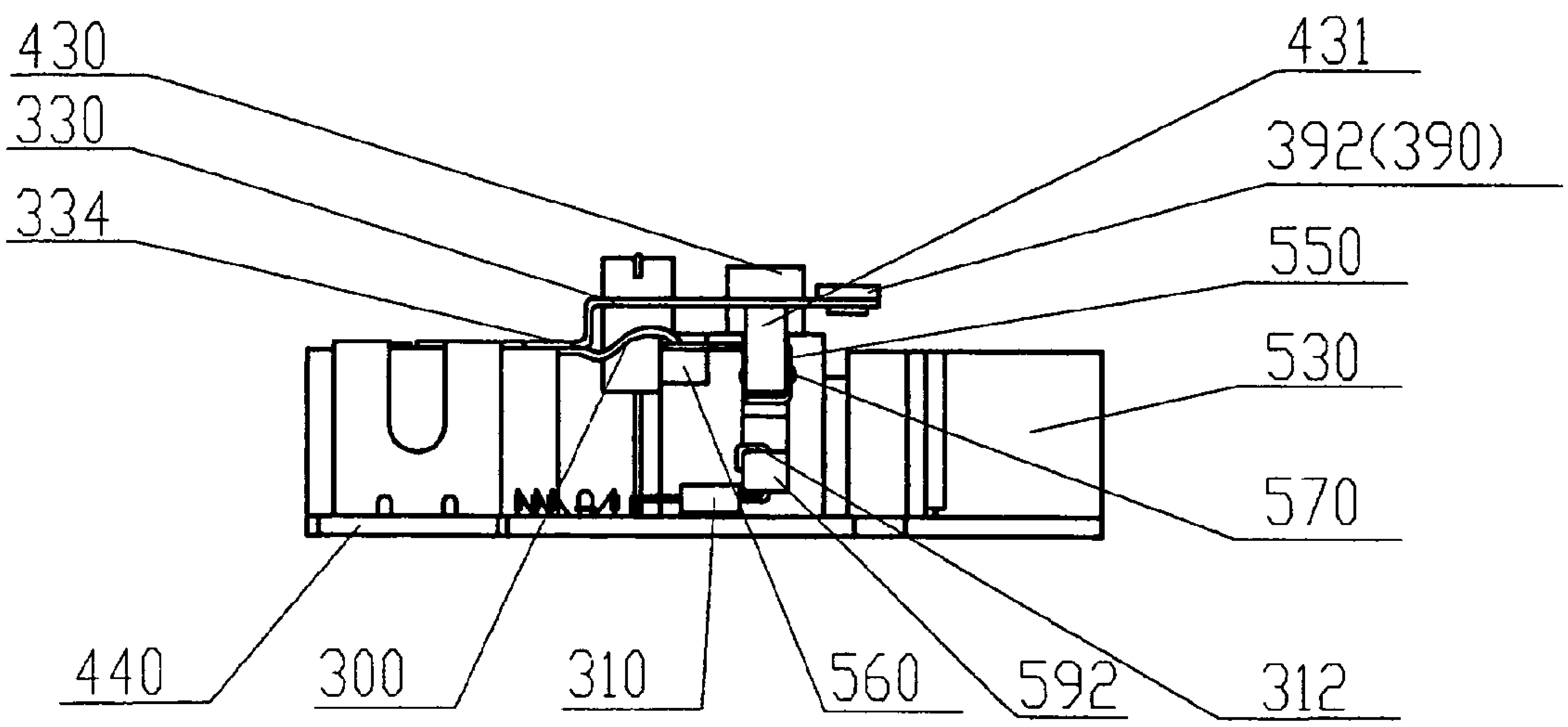


FIG.14

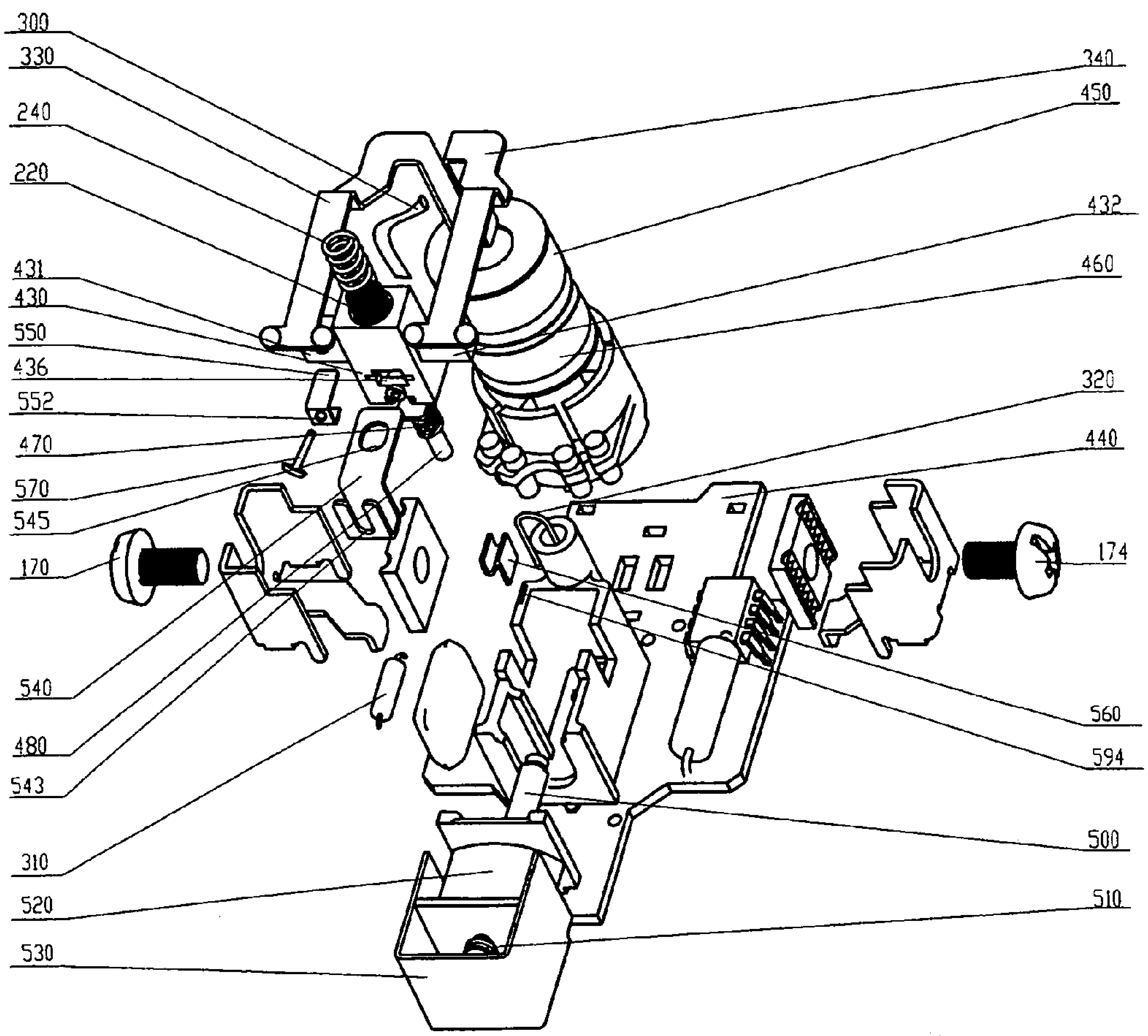

300
330
240
220
431
430
550
436
552
470
570
545
170
540
480
543
310
520
530
340
450
432
460
320
440
174
560
594
500
510

FIG.15

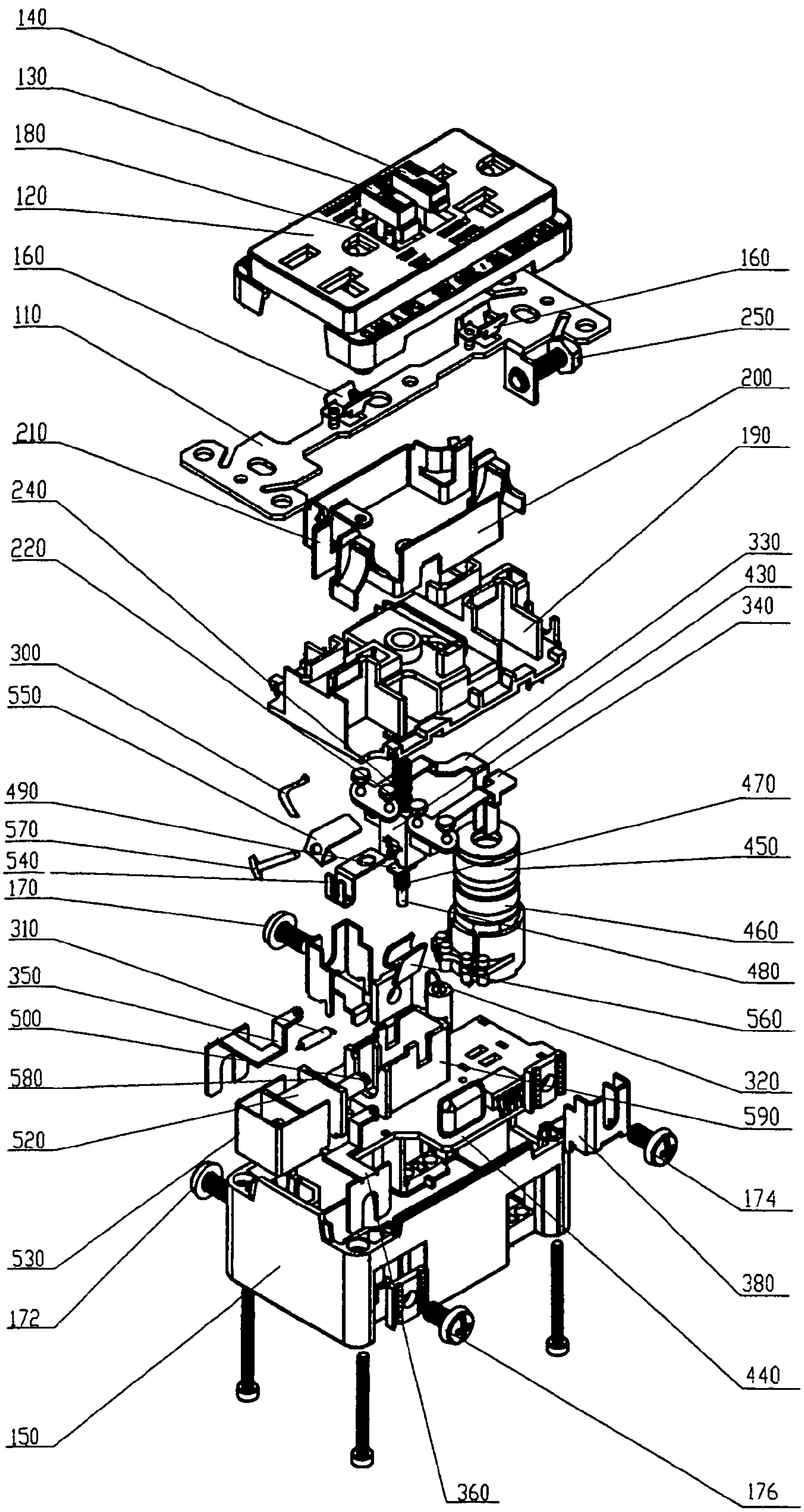

140
130
180
120
160
110
210
240
220
300
550
490
570
540
170
310
350
500
580
520
530
172
150
360
176
440
380
174
590
320
560
480
460
450
470
340
430
330
190
200
250
160

FIG.16A

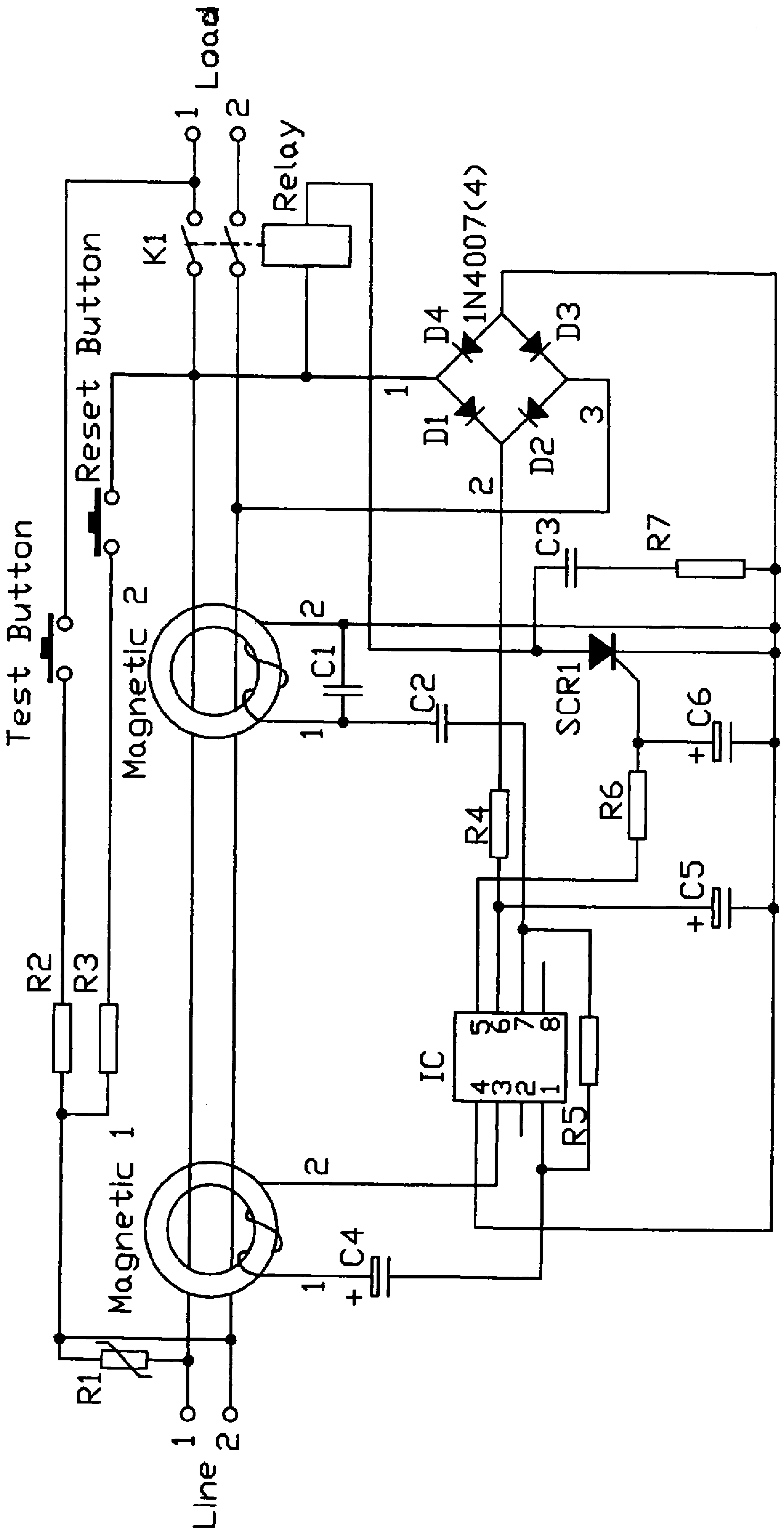
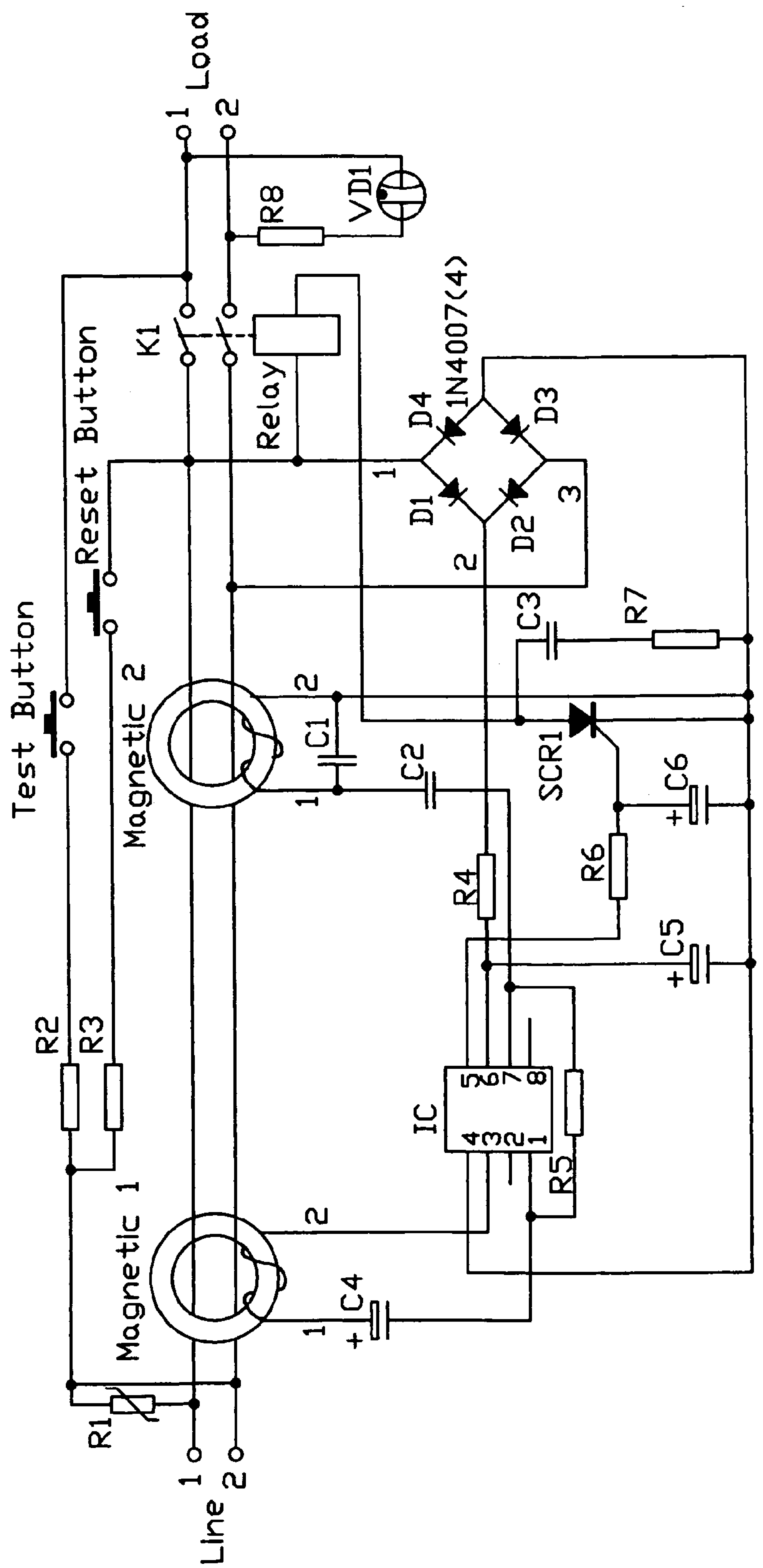

Load
Relay
K1
Reset Button
Test Button
Magnetic 2
Magnetic 1
1N4007(4)
D1
D2
D3
D4
SCR1
IC
R1
R2
R3
R4
R5
R6
R7
C1
C2
C3
C4
C5
C6
Line

FIG.16B


Load
Line
K1
Relay
VD1
R8
1N4007(4)
D1
D2
D3
D4
Test Button
Reset Button
Magnetic 1
Magnetic 2
R1
R2
R3
R4
R5
R6
R7
C1
C2
C3
C4
C5
C6
SCR1
IC

# GROUND FAULT CIRCUIT INTERRUPTER WITH REVERSE WIRING PROTECTION

This is a continuation-in-part of patent application Ser. No. 10/945,672, filed on Sep. 21, 2004.

## FIELD OF THE INVENTION

The present invention relates to a ground fault circuit interrupter (GFCI) device for protecting an alternating current load circuit, and more particularly to a GFCI with reverse wiring protection.

## BACKGROUND

With the increasing use of household electrical appliances, people demand that receptacles installed in their houses be capable of protecting them from serious injury when accidentally touched or other ground fault conditions occur. Thus, ground fault circuit interrupters are designed to break the electrical continuity upon detecting a ground fault condition occurring at an alternating current (AC) load.

Many electrical wiring devices including receptacles have a line side that is connectable to an electrical power supply, and a load side that is connectable to one or more loads and at least one conductive path between the line side and load side. When a person accidentally comes in contact with the line side of the AC load and an earth ground at the same time, a serious injury may occur because the human body forms another conductive path for the electrical current to flow through. There is a strong desire for electrical wiring devices that can break electric power supply to various loads such as household appliances and consumer electronic products.

The GFCI devices can detect a ground fault condition and break the electric power supply by employing a sensing transformer to detect an imbalance between the currents flowing in the phase (also known as “hot”) and neutral conductive paths of the power supply. A ground fault condition happens when the current is diverted to the ground through another path such as a human body, that results in an imbalance between the currents flowing in the phase and neutral conductors. Upon detection of a ground fault condition, a breaker within the GFCI devices is immediately tripped to interrupt the electrical continuity and removes all power supply to the loads.

Some circuit interrupters, such as GFCI receptacles, have a user accessible load in addition to the line side and load side connections. Users can connect other household appliances to the power supply through plug entries on the receptacle. However, due to the similarity of line side and load side terminals, instances may occur where the line wires are connected to the load side connection and the load wires are connected to the line side connection. This is known as reverse wiring. When reverse wiring occurs, the GFCI devices usually do not provide ground fault protection to the user accessible load. It is a problem if there is no warning provided to an installer when the GFCI devices have reverse wiring. Thus, it is desired to design a GFCI device which can disable the reset function when the GFCI device has reverse wiring. Moreover, it is strongly desired that a GFCI does not even provide electricity to user accessible loads to better protect consumers when there is reverse wiring.

In addition, because of the high stability requirement of the GFCI devices’ quality, it is also desired for GFCI devices to have a simpler design, less components so that they are easier to be assembled, installed, and correctly wired.



## SUMMARY OF THE PREFERRED EMBODIMENTS

One embodiment of the invented circuit interrupter comprises a pair of fixed contact strips, a pair of load contact strips, a pair of movable contact strips, a reset component, a movable component, and a tripping component that contains a reset contact. Each of the fixed contact strips has a fixed contact. Each of the load contact strips has a load contact. Each of the movable contact strips has a fixed end and a movable end. Each movable end has a first movable contact arranged for contacting one of the corresponding load contacts and a second movable contact arranged for contacting one of the corresponding fixed contacts. The movable component disposed to sustain the movable ends of the movable contact strips, the movable component capable of either being latched with or released from the reset component to move between a first position where the first movable contacts are separated from the load contacts, and the second movable contacts are separated from the fixed contacts, and the movable contact strips are not electrically coupled to the reset contact, a second position where the first movable contacts are separated from the load contacts, and the second movable contacts are separated from the fixed contacts, and at least one of the movable contact strips is electrically coupled to the reset contact, and a third position where the first movable contacts make contact with the corresponding load contacts, and the second movable contacts make contact with the corresponding fixed contacts, and the movable contact strips are not electrically coupled to the reset contact. The tripping component is capable of latching the reset component with the movable component for the movable component to move to the third position upon detection of a reset request and releasing the reset component from the movable component for movable component to move to the first position upon detection of a fault condition.

In the embodiment, the reset component, the movable component, and the tripping component employ some elastic tubes such as springs to achieve a reset function and a trip function. By using elastic forces, the embodiment has the advantages of less manufacturing costs, convenient assembling, and a stable quality.

## BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the present invention can be obtained by reference to the detailed description of embodiments in conjunction with the accompanying drawings. These drawings depict only a typical embodiment of the invention and do not therefore limit its scope. They serve to add specificity and details, in which:

FIG. **1** is a perspective view of an exemplary embodiment of a current interrupter;

FIG. **2** is a perspective view of the current interrupter in FIG. **1** with a face portion removed, illustrating the internal configuration;

FIG. **3**A is a perspective view of the current interrupter in FIG. **2** with a mounting strap and a middle body removed, further illustrating the internal configuration;

FIG. **3**B is a perspective view of the current interrupter in FIG. **3**A with split movable ends of the movable contact strips;

FIG. **4** illustrates a cross-sectional view of the current interrupter in FIG. **1** along the AA line in a reset condition;

FIG. **5** illustrates a cross-sectional view of the current interrupter in FIG. **1** along the AA line in a tripped condition;

FIG. **6** illustrates a cross-sectional view of the current interrupter in FIG. **1** along the BB line in a tripped condition;

FIG. **7** illustrates a cross-sectional view of the current interrupter in FIG. **1** along the BB line in a transient condition when a reset button is pressed;

FIG. **8** illustrates a cross-sectional view of the current interrupter in FIG. **1** along the opposite direction of BB line in a reset condition;

FIG. **9** illustrates a cross-sectional view of the current interrupter in FIG. **1** along the BB line in a reset condition;

FIG. **10** illustrates a cross-sectional view of the current interrupter in FIG. **1** along the CC line with a test component;

FIG. **11** illustrates a cross-sectional view of the current interrupter in FIG. **1** along the CC line in a transient condition when a test button is pressed;

FIG. **12** is a perspective view of the current interrupter in FIG. **3** with a rear portion removed;

FIG. **13** is left-to-right side view of the current interrupter in FIG. **12**;

FIG. **14** is an exploded view of the current interrupter in FIG. **12**;

FIG. **15** is an exploded view of the current interrupter in FIG. **1**;

FIG. **16**A is a schematic diagram of a control circuit in the current interrupter in FIG. **1**; and

FIG. **16**B is a schematic diagram of a control circuit in a current interrupter containing a reverse-wiring detection circuit.

## DETAILED DESCRIPTION

Patent application Ser. No. 10/945,672, filed on Sep. 21, 2004, by Ping Wang, is incorporated in its entirety.

As shown in FIG. **1**, an exemplary embodiment **100** of a ground fault current interrupter (GFCI) receptacle has a housing which comprises a face portion **120**, a middle body **190** (shown in FIG. **2**), and a rear portion **150**. The face portion **120** has entry ports **122**, **124** for receiving normal or polarized prongs of a male plug, as well as ground-prong-receiving openings **160** to accommodate a three-wire plug. The receptacle **100** contains a mounting strap **110** used to fasten the receptacle to a junction box. As shown in FIG. **2**, the mounting strap **110** has a threaded opening to receive a ground screw **250** for connecting to an external ground wire.

A reset button **130** extends through an opening in the face portion **120** of the housing. The reset button **130** is used to activate a reset operation which re-establishes the electrical continuity in open conductive paths. A test button **140** extends through an opening in the face portion **120** of the housing. The test button **140** is used to break the electrical continuity in close conductive paths by simulating a fault condition.

As shown in FIGS. **1** and **15**, electricity connects to the GFCI receptacle **100** through binding screws **170**, **172**, **174**, and **176** where the binding screw **170** is a line phase connection, the binding screw **174** is a line neutral connection, the binding screw **172** is a load phase connection, and the binding screw **176** is a load neutral connection. In addition to binding screws, people in the art will appreciate other types of wiring terminals such as set screws, pressure clamps, pressure plates, push-in type connections, pigtails, and quick-connect tabs.

As shown in FIGS. **2**, **3**, and **6**, the conductive path between the line neutral connection **174** and the load neutral connection **176** comprises a right movable contact strip **340** with one end electrically coupled to the line neutral connection **174** and the other end movable to establish and break the electrical continuity, a first right movable contact **400** mounted onto the left movable end of the right movable contact strip **340**, a right load contact strip **360** electrically coupled to the load neutral connection **176**, and a right load contact **270** mounted onto the right load contact strip **360**. A user accessible load neutral connection contains binding terminals capable of engaging a prong of a male plug inserted therebetween. The conductive path between the line neutral connection **174** and the user accessible load neutral connection comprises a right movable contact strip **340** with one end electrically coupled to the line neutral connection **174** and the other end movable to establish and break the electrical continuity, a second right movable contact **402** mounted onto the right movable end of the right movable contact strip **340**, a right fixed contact strip **200** electrically coupled to the binding terminals, and a right fixed contact **260** mounted onto the right fixed contact strip **200**.

Similarly, the conductive path between the line phase connection **170** and the load phase connection **172** comprises a left movable contact strip **330** with one end electrically coupled to the line phase connection **170** and the other end movable to establish and break the electrical continuity, a first left movable contact **390** mounted onto the right movable end of the left movable contact strip **330**, a left load contact strip **350** electrically coupled to the load phase connection **172**, and a left load contact **280** mounted onto the left load contact strip **350**. A user accessible load phase connection contains binding terminals capable of engaging a prong of a male plug inserted therebetween. The conductive path between the line phase connection **170** and the user accessible load phase connection comprises a left movable contact strip **330** with one end electrically coupled to the line phase connection **170** and the other end movable to establish and break the electrical continuity, a second left movable contact **392** mounted onto the left movable end of the left movable contact strip **330**, a left fixed contact strip **210** electrically coupled to the binding terminals, and a left fixed contact **290** mounted onto the left fixed contact strip **210**.

As shown in FIGS. **1**–**14**, the GFCI receptacle **100** contains the movable contact strips **330**, **340**, the fixed contact strips **200**, **210**, the load contact strips **350**, **360**, a reset component, a test component, a movable component, and a tripping component. A protruding contact **550** (shown in FIG. **14**) is electrically coupled to the left movable contact strip **330** for the reset operation. When the reset button **130** of the reset component is pressed, the reset component moves down and causes the left movable contact strip **330** to electrically connect to a reset resistor **310** through the protruding contact **550**. The tripping component is then activated to latch the reset component with the movable component. When the reset button **130** is released, the reset component moves up and brings the movable component up together. The movable component further pushes the movable ends of the movable contact strips **330**, **340** up to a position where first movable contacts **390**, **400** maintain a good contact with corresponding load contacts **280**, **270** and where second movable contacts **392**, **402** maintain a good contact with corresponding fixed contacts **290**, **260**. Accordingly, the reset operation re-establishes the electrical continuity between the line end and the load end as well as between the line end and the user accessible load end. When the test button **140** is pressed, the test component activates the tripping component to release the reset component from the movable component. The movable component moves down and causes the movable contacts **390**, **392**, **400**, **402** to separate from the fixed contacts **260**, **290** and the load contacts **270**, **280**. Accordingly, the test operation simulates a fault condition to break the electrical continuity.

The reset component comprises the reset button **130**, a reset shaft **180**, and a reset spring **240**. One end of the reset shaft **180** is molded into the underside of reset button **130** and the other end extends through the middle body **190** into the movable component. The reset spring **240** surrounds an upper portion of the reset shaft **180** and is partially disposed in a cup-shape portion of the middle body **190**. Thus, one end of the reset spring **240** props up the reset button **130** and the other end presses onto an upper surface of the middle body **190**. In other words, the reset spring **240** is restricted between the reset button **130** and the middle body **190**.

The movable component mainly disposed under the reset component comprises a movable assembly **430** and a latching plate **540**. The movable assembly **430** has a left sustaining portion **431** and right sustaining portion **432** (shown in FIG. **14**) extending under the movable ends of the movable contact strips **330**, **340**, respectively. As a result, when the movable assembly **430** moves up, the movable ends of the movable contact strips **330**, **340** are brought up to a position so that the first movable contacts **390**, **400** maintain a good contact with corresponding load contacts **280**, **270** and the second movable contacts **392**, **402** maintain a good contact with corresponding fixed contacts **290**, **260**. However, if the movable ends of the left movable contact strip **330** and the right movable contact strip **340** are not precisely on the same horizontal level, the contacts between left contacts (**390** and **280**, **392** and **290**) and the contacts between right contacts (**400** and **270**, **402** and **260**) may not be equally good. In one embodiment as shown in FIGS. **6**–**9**, supporting springs **410**, **420** are respectively disposed in spring cavities **433**, **434** on the sustaining portions **431**, **432** to adjust and improve these contacts. Covering plates (not shown) may be disposed on the top of the springs to electrically insulate the supporting springs **410**, **420** from the movable contact strips **330**, **340**. The supporting springs **410**, **420** respectively provide a separate elasticity to the movable contact strips **330**, **340** so that both right contacts and left contacts can maintain a good contact even when they are in a slightly different horizontal level.

As shown in FIG. **14**, the movable assembly **430** has a cavity, a middle spring **220**, a pair of latching slots **436**, a reverse shaft **480**, and a reverse spring **470**. The cavity with an opening on the top accommodates a lower portion of the reset shaft **180**. An upper portion of the cavity is wider so that the middle spring **220** can partially sit in and surround the lower portion of the reset shaft **180**. As a result, the middle spring **220** is restricted between a lower surface of the middle body **190** and the inner wall of the cavity. People in the art understand that under certain circumstances the middle spring **220** is not necessary to achieve the intended function. The reverse shaft **480** has one end attached to and under a lower plate **490** of the movable assembly **430** and the other end penetrating into a circuit board **440**. The reverse spring **470** surrounds the reverse shaft **480** and is restricted between the lower plate **490** of the movable assembly **430** and the circuit board **440**. The pair of latching slots **436** are disposed on both side walls of the movable assembly **430** allowing the latching plate **540** to extend through the movable assembly **430**.

The latching plate **540** has a latching portion with a latching hole **545** and a clasp portion with a clasp opening



**543**. The latching portion extends through the movable assembly **430** via the latching slots **436**. The latching hole **545** is disposed on the latching portion so that the reset shaft **180** can penetrate the latching hole **545** and latches with the latching plate **540** when the GFCI receptacle **100** is in a reset condition. The clasp opening **543** is arranged to allow the latching plate **540** to be able to move up and down while remaining to be clasped with the tripping component. In this embodiment, the clasp portion has a U-shaped opening **543**.

The tripping component comprises a trip shaft **500**, a trip spring **510**, an electromagnetic unit, and a control circuit. The electromagnetic unit contains a trip coil **520**, a shield plate **580** disposed right before the trip coil **520**, and a metal shield **530**. The metal shield **530** covers at least two sides of the trip coil **420** and is abutted against one side of the rear portion **150**. The trip shaft **500** has a first end clasped with the U-shaped clasp opening **543** in the clasp portion of the latching plate **540** and a second end disposed inside the trip coil **520**. A portion of the trip spring **510** surrounds a narrower portion of the trip shaft **500** at its second end. The remaining portion of the trip spring **510** forms a space for the movement of the trip shaft **500**. The trip spring **510** is restricted between the shield metal **530** and a constricting surface of the trip shaft **500**. The trip spring **510** can be in a conical shape or in a cylinder shape. When activated by the control circuit, the electromagnetic unit pulls the trip shaft **500** which in turn pulls the latching plate **540** so that the reset shaft **180** can be latched with or released from the latching hole **545**. To control the moving distance of the trip shaft **500**, the trip shaft may have a protruding portion **502** located before the shield plate **580** (as shown in FIG. **4**) to cease the movement when the protruding portion **502** touches the shield plate **580**. Similarly, the movable assembly accommodation base **590** may have a blocking portion extended before or after the latching plate **540** to control the moving distance of the trip shaft **500**.

The control circuit activates the electromagnetic unit upon detecting a ground fault condition, a test request, and a reset request. The control circuit has a reset resistor **310**, a reset contact **312**, a test resistor **320**, a sensing coil **460**, and a neutral coil **450**. The sensing coil **460** and the neutral coil **450** detect a fault condition. The reset contact **312** is disposed to contact with the protruding contact **550** to activate the reset operation. In one embodiment, the reset contact **312** is a portion of the reset resistor **310**. As shown in FIG. **13**, the reset contact **312** is disposed on the top of a fixing stand **592** which is a portion of the movable assembly accommodation base **590**. In another embodiment, the reset contact **312** is a conductive strip disposed to be electrically coupled to the reset resistor **310**. When the reset button **130** is pressed down to cause the protruding contact **550** to contact with the reset contact **312**, the left movable contact strip **330** is electrically coupled to the reset resistor **310** so that a close circuit is formed and a diverted current is generated. Accordingly, the control circuit activates the electromagnetic unit to perform the reset operation. Similarly, the control circuit activates the electromagnetic unit when a test strip **230** is pressed down to contact a test resistor **320** and to form a close circuit.

The GFCI receptacle **100** is originally stable at a trip condition as shown in FIGS. **5** and **6**. The movable component is at a first position where movable ends of the movable contact strips **330**, **340** stay on the sustaining portions **431**, **432** of the movable assembly **430** and are separated from the fixed contact strips **200**, **210** and load contact strips **350**, **360**. The left movable contact strip **330** is not electrically coupled to the reset resistor **310**. The movable assembly **430** is at a stabilized position due to the balance among the reset spring **240**, the middle spring **220**, and the reverse spring **470**.

After the GFCI receptacle **100** is correctly wired, the reset button **130** is pressed to establish the electrical continuity in the conductive paths. When the reset button **130** is pressed, the reset shaft **180** moves down to push onto a surface of the latching plate **540**. The latching plate **540** brings the movable assembly **430** to move down. The movable ends of the movable contact strips **330**, **340** move down due to their own elasticity. The left movable contact strip **330** is electrically coupled to the reset resistor **310** to form a close circuit and to generate a reset request. In one embodiment, the protruding contact **550** is electrically coupled to the left movable contact strip **330** through a connecting strip **300**. The protruding contact **550** is attached to the left sustaining portion **431** of the movable assembly **430** by inserting a rivet **570** through a fastening hole **552** on the protruding contact **550** and a corresponding hole **437** on the left sustaining portion **431** of a movable assembly **430**. People with ordinary skills in the art will appreciate other ways to attach the protruding contact **550** to the left sustaining portion **431** of the movable assembly **430**. The connecting strip **300** connects the protruding contact **550** and a connecting portion **334** of the left movable contact strip **330**. The connecting strip **300** may comprise copper. Materials such as a soft copper cord or a copper strip can be used. In another embodiment, the left movable contact strip **330** contains a protruding contact **550**. The movable assembly **430** is at a transient second position where the movable ends of the movable contact strips **330**, **340** are separated from the fixed contact strips **200**, **210** and load contact strips **350**, **360**. At the same time, the left movable contact strip **330** is electrically coupled to the reset resistor **310**, either directly or indirectly, to activate a reset operation.

Because of the closed circuit resulting from the electric connection, the control circuit activates the electromagnetic unit to pull the trip shaft **500**. The trip shaft **500** then pulls the latching plate **540** by overcoming friction force between the reset shaft **180** and the latching plate **540** as well as the elastic force from the pressed trip spring **510**. When the latching hole **545** moves to a position right under the reset shaft **180**, a head portion of the reset shaft **180** penetrates the latching hole **545**. At the moment, because the pressure given onto the latching plate **540** by the reset shaft **180** vanishes, the pressed reverse spring **470** bounces back to move the movable assembly **430** up. The left sustaining portion **431** of the movable assembly **430** pushes the left movable contact strip **330** up. As a result, the protruding contact **550** separates from the reset contact **312**. Because of the open circuit resulting from the separation, the control circuit inactivates the electromagnetic unit to cease the pulling force. The pressed trip spring **510** then bounces back to push the latching plate **540** and causes a neck portion of the reset shaft **180** to latch with the latching hole **545**.

When the reset button is released, the pressed reset spring **240** bounces back to move up the reset shaft **180**. The reset shaft **180** brings up the movable assembly **430** through the latching plate **540** that latches with the reset shaft **180**. Overcoming the elastic forces from the pressed middle spring **220** and the movable contact strips **330**, **340**, the movable assembly **430** with the sustaining portions **431**, **432** pushes the movable ends of the movable contact strips **330**, **340** to a position where the first movable contacts **390**, **400** maintain a good contact with the respective load contacts **280**, **270** and the second movable contacts **392**, **402** maintain a good contact with the respective fixed contacts **290**, **260**. The movable assembly **430** is then at a third position when the GFCI receptacle **100** is at a reset condition.

The receptacle **100** may include a resistive strip **560** disposed in a way to cause a transient blocking effect when the reset button **130** is pressed down to initiate a reset operation. In one embodiment, the resistive strip **560** is attached to a movable assembly accommodation base **590** and extends under the left sustaining portion **431** of movable assembly **430** by inserting a portion of the resistive strip **560** into an insertion slot **594** on the base **590**. When the reset button **130** is pressed, the reset shaft **180** moves down to push onto the surface of the latching plate **540**. The latching plate **540** brings the movable assembly **430** to move down. At this moment, the resistive strip temporarily blocks the movement of the movable assembly **430**. After the reset button **130** is pressed with more force, the movable assembly **430** overcomes the elastic force of the resistive strip **560** and continues to move down. In one embodiment, the resistive strip **560** comprises stainless steel and is in an upwardly curved shape. People in the art understand that other material with good elasticity can be used and the resistive strip **560** can be made in other shapes. In addition, to increase the resistivity, a spring may be disposed under the resistive strip **560** and be supported by a stand extended from the movable assembly accommodation base **590**. Although the resistive strip **560** may comprise metal, it does not form any part of the control circuit or conductive paths. The resistive strip **560** can prevent children from accidentally pressing down the reset button **130** and activating the reset operation.

As another embodiment shown in FIG. 3B, the movable ends of movable contact strips **330**, **340** can be split into two sub-strips from an appropriate place with first movable contacts **390**, **400** and second movable contacts **392**, **402** respectively located on each of the sub-strip. For example, the first left movable contact **390** is located on an inner sub-strip of the left movable contact strip **330**; the second left movable contact **392** is located on an outer sub-strip of the left movable contact strip **330**; the first right movable contact **400** is located on an inner sub-strip of the right movable contact strip **340**; the second right movable contact **402** is located on an outer sub-strip of the right movable contact strip **340**. People in the art understand that the shape of the movable contacts strips **330**, **340**, the load contact strips **350**, **360**, and the fixed contact strips **200**, **210**, and the location of these contact strips may vary as long as four contact pairs, the first left movable contact **390** corresponding to the left load contact **280**, the second left movable contact **392** corresponding to the left fixed contact **290**, the first right movable contact **400** corresponding to the right load contact **270**, and the second right movable contact **402** corresponding to the right fixed contact **260** maintain a good contact when in a reset condition.

In addition, people in the art will appreciate that other elastic materials such as elastic tubes can be used to replace the reset spring **240**, the middle spring **220**, the reverse spring **470**, and the trip spring **510**. In this embodiment, the load contacts **280**, **270** and the fixed contacts **290**, **260** have a flat contact surface and the first movable contacts **390**, **400** and the second movable contacts **392**, **402** have a protruding contact surface, such as a hemispherical shape. In this embodiment, all contacts comprise copper alloy and the contacting surfaces of all contacts are coated with silver alloy. People in the art understand that the load contacts **280**, **270**, the fixed contacts **290**, **260**, the first movable contacts **390**, **400**, and the second movable contacts **392**, **402** can be made in other shapes and by other materials. In this embodiment, the reset shaft **180** and the reverse shaft **480** comprise steel. The trip shaft **500** comprises iron. People in the art understand other materials can be used to make the reset shaft **180**, the reverse shaft **480**, and the trip shaft **500**. In this embodiment, when activated by the control circuit, the electromagnetic unit pulls the trip shaft **500** so that the reset shaft **180** can be latched with or released from the latching hole **545**. However, people in the art appreciate that when activated by the control circuit, the electromagnetic unit can also push the trip shaft **500** to achieve the same results.

If the GFCI receptacle **100** has a reverse wiring, the control circuit is not supplied with electricity to activate the electromagnetic unit when the protruding contact **550** contacts the reset contact **312** and the reset function is disabled. In other words, when the GFCI receptacle **100** is in a trip condition, the control circuit is connected to the line side of the GFCI receptacle **100** only and is not connected to the load side. As a result, if the line wires are connected to the load side of the GFCI receptacle **100**, no power supply is provided to the control circuit and the reset function is disabled. In detail, because the latching plate **540** is not pulled to allow the reset shaft **180** to penetrate the latching hole **545**, the reset shaft **180** does not latch with the latching plate **540**. Thus, when the reset button **130** is released, due to the elastic force from the pressed reset spring **240**, the reset shaft **180** moves up alone without bringing up the movable assembly **430**. When the latching plate **540** is not pressured by the reset shaft **180**, the pressed reverse spring **470** bounces back to move up the movable assembly **430**. After the elastic forces from the reverse spring **470**, the middle spring **220**, and the movable contact strips **330**, **340** reach a balance, the movable assembly **430** comes back to the first position where movable ends of the movable contact strips **330**, **340** separate from the fixed contact strips **200**, **210** and the load contact strips **350**, **360**. The GFCI receptacle **100** remains in the trip condition. Failure to reset the GFCI receptacle **100** provides a warning of the reverse wiring. When an installer cannot reset the GFCI receptacle **100**, he realizes that it is wrongly wired and is able to correct the wiring instantly.

In addition, to provide a better protection, if there is a reverse wiring which means line wires are connected to the load ends, the GFCI receptacle **100** cannot function as a receptacle at all and no electricity is provided to any plug-in electronic apparatus. It prevents people from using the receptacle without the protection of ground fault current interruption. Besides, an installer or a user can easily find out the reverse wiring and correct it. Otherwise, people cannot use the GFCI receptacle **100** at all. As described above, because the control circuit is not provided with electricity to perform a reset operation, the GFCI receptacle **100** remains in a trip condition even after the reset button **130** is pressed. There is no conductive path between the load end connections **172**, **176** and the binding terminals of user accessible load connections **122**, **124** because the load contact strips **350**, **360** are separated from the movable contact strips **330**, **340**.

The receptacle **100** may further contain a reverse-wiring detection circuit to indicate a reverse-wiring condition and to warn an installer by lights or sounds. The reverse-wiring circuit may include a diode, a resistor, and a signal-generating device. The signal-generating device can be a light emitting diode (LED) or an alarm. The LED can be disposed on any location of the face portion **120** as long as lights from the LED can be seen from the top of the receptacle **100**. Skilled artisans know there are several ways to apply the LED for signaling a reverse-wiring. For example, when there is a reverse wiring, the red LED turns on to warm an installer and a user. When there is a correct wiring, the green LED turns on to assure that the GFCI receptacle **100** works in a good condition. More than two LEDs may be used. For example, a red LED turns on when there is a reverse wiring and a green (or blue or yellow) LED turns on when there is a correct wiring. As shown in FIG. **16**B, an embodiment has a reverse-wiring detection circuit that includes a resistor R**8** and an LED component VD**1**. The LED component contains an LED and a diode. When the GFCI is installed with a reverse wiring, the LED turns on to warn an installer.

A test mechanism is installed to test whether the electrical continuity can be broken by simulating a ground fault condition. The test component comprises the test button **140** and the test strip **230**. One end of the test strip **230** is electrically coupled to the left fixed contact strip **210** and the other end hangs under the test button **140**. When the electrical continuity is established and the test button **140** is pressed, the test button **140** pushes the test strip **230** down to contact the test resistor **320** of the control circuit. As a result, the control circuit activates the electromagnetic unit to pull the trip shaft **500**. Overcoming the elastic force from the trip spring **510**, the trip shaft **500** pulls the latching plate **540** to release the reset shaft **180** from the latching hole **545**. The pressed reset spring **240** further moves the reset shaft **180** and the reset button **130** up. After releasing from the reset shaft **180**, the movable assembly **430** and the latching plate **540** move down due to the elastic forces from the pressed middle spring **220** and the movable contact strips **330**, **340**. The movable ends of the movable contact strips **330**, **340** move down and separate from both the fixed contact strips **200**, **210** and the load contact strips **350**, **360**. When the downward elastic force balances the upward elastic force from the pressed reverse spring **470**, the movable assembly **430** is stabilized at the first position where the movable ends of the movable contact strips **330**, **340** separate from the fixed contact strips **200**, **210** and the load contact strips **350**, **360**. The protruding contact **550** separates from the reset contact **312** so that the left movable contact strip **330** is not electrically coupled to the reset resistor **310**. As a result, the electrical continuity is broken and the GFCI receptacle **100** is in a trip condition.

When the control circuit detects a ground fault condition, it activates the electromagnetic unit to pull the trip shaft **500**. The remaining process is the same as that of the test operation.

FIG. **16** shows an exemplary embodiment of the control circuit and its relationship with other components of the GFCI receptacle **100**. Line **1** is the line phase connection and line **2** is the line neutral connection. Similarly, load **1** is the load phase connection and load **2** is the load neutral connection. The phase and neutral conductive paths of the line side pass through both a sensing transformer U1 (**460**) and a neutral transformer U2 (**450**) that are used to detect the imbalance of the currents between the phase and the neutral conductive path.

A resistor R**5** connects between the terminal **1** and terminal **7** of an RV 4145 IC. The magnitude of the resistor R**5** determines the threshold value for the tripping action of the GFCI receptacle **100** to occur. In other words, if the control circuit detects a current imbalance greater than the threshold value, it activates the electromagnetic unit to break the electrical continuity. In this embodiment, the threshold value is about 4–6 mA.

In the absence of a ground fault condition, the currents following through the phase and neutral conductive paths are equal and opposite. No net flux is generated in the core of the sensing transformer U1 (**460**). In the event that the current is diverted because of another electrical connection between the phase conductor of the load side and the ground, the currents flowing through the phase and neutral conductors are unequal and a net flux is generated. When the flux reaches the threshold value determined by the resistor R**5**, the terminal **5** of the IC generates a signal to activate the trip coil **520** of the electromagnetic unit ("Relay" shown in FIG. **16**). As a result, the trip shaft **500** pulls the latching plate **540** so that the reset shaft **180** releases from the latching plate **540**, and the electrical continuity between the first movable contacts **390**, **400** and the load contacts **280**, **270** and between the second movable contacts **392**, **402** and the fixed contacts **290**, **260** is interrupted.

When the GFCI receptacle **100** is in a trip condition and the reset button **130** is pressed, a diverted current flows from line **1** through the reset resistor **310** ("R**3**" shown in the FIG. **16**), the protruding contact **550**, the connecting strip **300**, and the left movable contact strip **330** to the line **2**. An imbalance of the currents flowing through the phase and neutral conductive paths is generated so that terminal **5** of the IC sends a signal to activate the trip coil **520** of the electromagnetic unit. As mentioned above, because the trip shaft **500** pulls the latching plate **540** to latch the reset shaft **180** with the latching hole **545**, the movable assembly **430** moves up to the third position where the first movable contacts **390**, **400** maintain a good contact with the respective load contacts **280**, **270** and the second movable contacts **392**, **402** maintain a good contact with the respective fixed contacts **290**, **260**. The electrical continuity is established.

When the GFCI receptacle **100** is in a reset condition and the test button **140** is pressed, a diverted current flows from line **1** through the test resistor **320** (R**2**), the test strip **230**, and the left fixed contact strip **210** to the line **2**. An imbalance of the currents flowing through the phase and neutral conductive paths is generated so that terminal **5** of the IC sends a signal to activate the trip coil **520** of the electromagnetic unit. As mentioned above, because the trip shaft **500** pulls the latching plate **540** to release the reset shaft **180** from the latching hole **545**, the movable assembly **430** moves down to the first position where the first movable contacts **390**, **400** separate from the respective load contacts **280**, **270** and the second movable contacts **392**, **402** separate from the fixed contacts **290**, **260**. The electrical continuity is broken.

Although the invention has been described in terms of exemplary embodiments, it is not limited thereto. The described embodiment is to be considered in all respects only as illustrative and not as restrictive. The present invention may be embodied in other specific forms without departing from its essential characteristics. The scope of the invention, therefore, is indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of the equivalents of the claims are to be embraced within their scope.

What is claimed is:

**1**. A circuit interrupter comprising:

a pair of fixed contact strips, each of the fixed contact strips having a fixed contact;

a pair of load contact strips, each of the load contact strips having a load contact;

a pair of movable contact strips, each of the movable contact strips having a fixed end and a movable end, the movable end of each movable contact strip split into two sub-strips, each of the movable ends having a first movable contact disposed on one sub-strip arranged for contacting one of the corresponding load contacts and a second movable contact disposed on the other sub-strip arranged for contacting one of the corresponding fixed contacts;

a reset component;

a tripping component comprising a reset contact;

a movable component disposed to sustain the movable ends of the movable contact strips, the movable component capable of either being latched with or released from the reset component to move between a first position where the first movable contacts are separated from the load contacts, and the second movable contacts are separated from the fixed contacts, and the movable contact strips are not electrically coupled to the reset contact, a second position where the first movable contacts are separated from the load contacts, and the second movable contacts are separated from the fixed contacts, and at least one of the movable contact strips is electrically coupled to the reset contact, and a third position where the first movable contacts make contact with the corresponding load contacts, and the second movable contacts make contact with the corresponding fixed contacts, and the movable contact strips are not electrically coupled to the reset contact;

wherein the tripping component capable of latching the reset component with the movable component for the movable component to move to the third position upon detection of a reset request and capable of releasing the reset component from the movable component for the movable component to move to the first position upon detection of a fault condition.

**2**. The circuit interrupter of claim **1**, wherein

the load contacts and the fixed contacts have a flat contact surface; and

the first movable contacts and the second movable contacts have a protruding contact surface.

**3**. The circuit interrupter of claim **2**, wherein

the contact surfaces comprise silver.

**4**. The circuit interrupter of claim **1**, further comprising:

a resistive strip disposed in a way to cause a transient blocking effect when the movable component moves from the first position to the second position.

**5**. The circuit interrupter of claim **1**, wherein

the reset component comprises a reset button, a reset shaft attached to the reset button, and a reset spring surrounding an upper portion of the reset shaft.

**6**. The circuit interrupter of claim **5**, wherein

the movable component comprises a movable assembly and a latching plate capable of being latched with the reset shaft and holding the movable assembly to move between different positions.

**7**. The circuit interrupter of claim **6**, wherein

the movable assembly comprises sustaining portions extended under the movable ends of the movable contact strips, a cavity to accommodate a lower portion of the reset shaft, at least one latching slot for the latching plate to insert, a reverse shaft attached to a lower plate of the movable assembly, and a reverse spring surrounding the reverse shaft.

**8**. The circuit interrupter of claim **7**, wherein

the movable assembly further comprises a middle spring disposed in the cavity and surrounding the lower portion of the reset shaft.

**9**. The circuit interrupter of claim **7**, further comprising:

a pair of supporting springs respectively disposed in a spring cavity on the sustaining portions of the movable assembly; and a pair of covering plates respectively disposed on a top of each supporting spring.

**10**. The circuit interrupter of claim **7**, wherein

the tripping component comprises a trip shaft capable of being clasped with the latching plate, a trip spring surrounding the trip shaft, an electromagnetic unit capable of moving the trip shaft, and a control circuit to activate the electromagnetic unit upon detecting a predetermined condition.

**11**. The circuit interrupter of claim **1**, further comprising:

a strap for mounting the circuit interrupter and for providing a grounding connection; and

a housing to accommodate the movable contact strips, the fixed contact strips, the load contact strips, the reset component, the movable component, and the tripping component.

**12**. A circuit interrupter comprising:

a pair of fixed contact strips, each of the fixed contact strips having a fixed contact;

a pair of load contact strips, each of the load contact strips having a load contact;

a pair of movable contact strips, each of the movable contact strips having a fixed end and a movable end, the movable end of each movable contact strip split into two sub-strips, each of the movable ends having a first movable contact disposed on one sub-strip arranged for contacting one of the corresponding load contacts and a second movable contact disposed on the other sub-strip arranged for contacting one of the corresponding fixed contacts;

a reset component comprising a reset button, a reset shaft attached to the reset button, and a first elastic tube surrounding an upper portion of the reset shaft;

a movable component comprising a movable assembly and a latching plate capable of being latched with the reset shaft and holding the movable assembly to move between different positions;

a trip component comprising a trip shaft capable of being clasped with the latching plate, a second elastic tube, an electromagnetic unit capable of moving the trip shaft, and a control circuit to activate the electromagnetic unit upon detecting a predetermined condition.

**13**. The circuit interrupter of claim **12**, wherein

the movable assembly comprises sustaining portions extended under the movable ends of the movable contact strips, a cavity to accommodate a lower portion of the reset shaft, at least one latching slot for the latching plate to insert, a reverse shaft attached to a lower plate of the movable assembly, and the third elastic tube surrounding the reverse shaft.

**14**. The circuit interrupter of claim **13**, wherein

The movable assembly further comprises a forth elastic tube disposed in the cavity and surrounding the lower portion of the reset shaft.

**15**. The circuit interrupter of claim **13**, wherein

the latching plate comprises a latching portion and a clasp portion, the latching portion extending through the latching slot into the movable assembly and having a latching hole for the reset shaft to penetrate, the clasp portion outside the movable assembly having an opening for clasping.

**16**. The circuit interrupter of claim **15**, wherein

the clasping portion of the latching plate has a U-shape opening that is capable of moving up and down between different positions while the trip shaft remains clasped with the opening of the latching plate.

**17**. The circuit interrupter of claim **15**, wherein

the electromagnetic unit comprises a trip coil, a shield plate, and a metal shield;

the trip shaft is partially disposed inside the trip coil; and

the electromagnetic unit, when activated, moving the trip shaft and compress the second elastic tube so that the reset shaft can penetrate into or remove from the latching hole.

**18**. The circuit interrupter of claim **17**, wherein

the trip shaft has a wider portion before the shield plate to control a moving distance of the trip shaft.

**19**. The circuit interrupter of claim **12**, further comprising:

a movable assembly accommodation base, a blocking portion of the movable assembly accommodation base extending before or after the latching plate to control a moving distance of the trip shaft.

**20**. The circuit interrupter of claim **14**, wherein the first elastic tube is a reset spring, the second elastic tube is a trip spring, the third elastic tube is a reverse spring, and the fourth elastic tube is a middle spring.

**21**. The circuit interrupter of claim **20**, wherein the reset spring has a larger elastic force than that of the middle spring.

**22**. The circuit interrupter of claim **20**, further comprising:

a middle body disposed between the reset component and the movable component, the middle structure containing an opening through which the reset shaft penetrates;

a circuit board disposed under the reverse shaft, the circuit board containing an opening through which the reverse shaft can penetrate.

**23**. The circuit interrupter of claim **22**, wherein

the reset spring is restricted between the reset button and a upper surface of the middle body, the middle spring is restricted between the lower surface of the middle body and a inner wall of the cavity of the movable assembly, the reverse spring is restricted between a lower surface of the lower plate of the movable assembly and an upper surface of the circuit board; the trip spring is restricted between a constricting surface of the trip shaft and the metal shield.

**24**. The circuit interrupter of claim **12**, further comprising:

a test component comprising a test button and a test strip, the test strip having one end hung under the test button and the other end electrically connected to the fixed contact strip.

**25**. The circuit interrupter of claim **12**, further comprising:

a reverse-wiring detection circuit comprising a signal-generating device to detect and signal a reverse wiring.

**26**. The circuit interrupter of claim **25**, wherein

the signal-generating device comprises at least one light emitting diode.

**27**. A circuit interrupter comprising:

a pair of fixed contact strips, each of the fixed contact strips having a fixed contact;

a pair of load contact strips, each of the load contact strips having a load contact;

a pair of movable contact strips, each of the movable contact strips having a fixed end and a movable end, the movable end of each movable contact strip split into two sub-strips, each of the movable ends having a first movable contact disposed on one sub-strip arranged for contacting one of the corresponding load contacts and a second movable contact disposed on the other sub-strip arranged for contacting one of the corresponding fixed contacts;

a reset component;

a movable means for being latched with or released from the reset component to move the movable ends of the movable contact strips between at least two different position;

a tripping means, when activated, for moving a portion of the movable means to latch the reset component with the movable means or to release the reset component from the movable means.

**28**. The current interrupter of claim **27**, wherein

at one position, the movable contact strip is capable of forming a close circuit to activate the tripping means and reset the current interrupter.

**29**. The circuit interrupter of claim **12**, wherein the control circuit comprises a reset contact.

**30**. The circuit interrupter of claim **29**, wherein the reset contact is electrically coupled to a reset resistor.

**31**. The circuit interrupter of claim **12**, wherein when the reset button is pressed, one of the removable contact strips is capable of activating the electromagnetic unit for reset operation.

**32**. The circuit interrupter of claim **29**, wherein when the reset button is pressed, one of the movable contact strips is electrically coupled with the reset contact to activate the electromagnetic unit for reset operation.

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